EVGENY PATON

Reminiscences

Foreign Languages Publishing House
MOSCOW

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E. PATON
(1870-1953)

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Part One

PLACE IN LIFE

1. THE CHOICE

I WAS BORN IN 1870 into the family of former Colonel of the Guards Paton, then Russian Consul in Nice.

It was the year when the Franco-Prussian War broke out. Somewhere, far from the Mediterranean, thousands of plain people died in battle, while here, under the azure skies of the beautiful south, the sea murmured gently, olives and oranges, magnolias and almonds were in full blossom, the crowns of eucalyptus-trees swayed in the light wind, it was warm all year round, and the air was scented with the fragrance of flowers.

Here in Nice, in the principal city of the Department of Alpes-Maritimes, at the most fashionable resort of the European aristocracy, everything disposed to indolence and dissipation. Since early childhood I had seen in the streets and on the embankments of Nice crowds of rich idlers, wealthy debauchées of all nationalities, who squandered money and searched for extraordinary recreation. The luxury of life about us seemed to suggest that in order to live like that one needed money, plenty of money, and that to get it any means were fair. One had only to learn from the few lucky ones to find a place in the sun, to throw all scruples to the winds and remember that in this world every man was for himself.

Our family lived a different life.

My father had been living abroad for many years and frequently confessed to us he was terribly homesick. He was afraid that his children, who were born abroad, might grow up without kith or kin and contract the contagious and loathsome disease—the most dangerous of all known diseases—the passion for personal gain and idleness. He considered the very air of our motherland beneficial and often sent the family to Russia for the summer. In later years my father was genuinely happy that I had served my time as a soldier in Russia.

I both loved and feared my father. He was stern and taciturn, rarely giving vent to his feelings, but a sympathetic and genial man just the same. Strict discipline reigned in the family. There were seven of us children—five brothers and two sisters. Father hated idleness more than anything else. He shut his eyes to much of what the girls did, but we boys had to toe the line. He expected us all to speak Russian at home, but he also insisted that we learn French, English and German, something for which I have always been thankful to him.

Like my brothers and sisters I was tutored at home before going to secondary school. Though school was easy to me I was anxious to have it over with, for close by there was the wonderful and mysterious sea. My childhood memories are bound up with the sea, the music of the tides and the beauty of sunrise and sunset.

Like any boy born on the sea-shore I could think of nothing but seafaring and often pictured myself, spyglass in hand, standing on the captain's bridge of an ocean liner. My mother would chuckle when I confided my childish dreams to her. Indeed, all boys there wanted to be captains fearlessly sailing the seven seas. And so, kissing my mother's hand, I ran off again to my toy yachts and frigates.

I did not know at the time that my mother had long since chosen for me a more prosaic, but, in her opinion, a more brilliant career.

As the years wore on I noticed that whenever I walked into the living-room mother and father broke off their conversation and ordered me out. One day, however, a dispute flared up in my presence.

Mother wanted her children to be "independent people" for whom others would work. I am sure she wished us all well, but she had her own ideas about what was best for us.

She could not think of her boys as petty government officials waiting for promotion from year to year. She knew her daughters would marry and make a good match, but the sons would have to become officers of the Guards, courtiers, landlords. All in all she was for an aristocratic career.

"Don't you understand," she would say to father, "it is our sacred duty to see that our children succeed and attain to a high position in life?"

Father had no use for such plans. He always detested the role of a landlord; his own estate in the Novgorod Gubernia had been mortgaged and remortgaged several times. Having served in the army till the age of forty, he, a military engineer, knew well what the "tsar's service" in Russia of that time meant. He, too, wanted to see his children independent, but in a different sense; their independence was to be won through honest labour rather than parasitism.

Mother thought, and not without reason, that the financial affairs of the family could be easily adjusted if it were not for father's obstinate and proud character, his unwillingness and inability to get along with the Petersburg officials, the minister and the court. She believed that all father had to do was to moderate his pride a little, and then he would surely be offered something better than a consular office in a resort town. And along

with a promotion there would come money, so much money, in fact, as to enable us to put our ruined estate in order. But if the husband couldn't or wouldn't master himself why should the children suffer?

Mother was able to get things partly her own way: all of us five boys were enrolled in the pages' corps. To be sure, her victory was incomplete; only two of us, the oldest, father really sent to the pages' corps in Petersburg, and mother no longer had to worry at least about those two for she believed that school to lead straight to a brilliant career. My other brothers and me father sent to secondary school.

We went to school in Stuttgart. Father believed the German curricula to be more thoroughgoing than the French. Mother had to go to Stuttgart with us. The principal of the Realschule, where I was enrolled directly in the seventh grade, was a mathematician, and the exact sciences formed the core of the curriculum, which meant that I had to work hard in order to catch up with my class-mates. Latin, which began in the fourth grade, had me really worried, but having previously acquired hard working habits I was now able to apply myself with as much assiduity and energy as was necessary to master it and not be ashamed of myself or blush before my class-mates.

Mother did not stay very long with us in Stuttgart; she had to go to Russia in order somehow to adjust our endless troubles with the estate.

My brothers and I refused to move to a boarding-house for foreigners. We could not stand the boring pedantry of the tutors, the regimented life and the eternal fault-finding of the monitors. We preferred freedom.

On Sundays and on Whitsunday we would walk or cycle to Schwarzwald. What a joy it was to roam through the mountain woods, sleep on the rocky banks of a murmuring river, make bonfires and feel independent and as free as a bird!

Lying on my back, face to the large summer stars, I let my imagination carry me far, far away.

One more year and good-bye school! Thanks to father for having delivered me from the career of my older brothers. But what was to become of me? I should certainly become a civil engineer; I had long since made up my mind. Father hardly even suspected I had forever memorized his stories about famous Russian engineers many of whom he knew personally. To build, to create for the joy of mankind,—is there anything more beautiful or more fascinating? I recalled the poverty-stricken little villages of Byelorussia I had visited on several occasions, the bumpy, broken-up roads, the God-forsaken, poor towns. How great the need for daring, vigorous and competent people there!

The distant stars twinkled softly over Schwarzwald, the fire crackled merrily, and at that moment I imagined myself a hero capable of the very greatest deeds. If only I grew up sooner, to go into the world and get a higher education...

A year passed but I was unable to leave school. Father was transferred to the Consulate in Breslau. Soon he was followed by part of our family including myself. The school I now entered was headed by a dyed-in-the-wool linguist and it was but natural for languages to flourish there. The language requirements were simply Draconian.

"I rather lose a year," I told my father, "but catch up with my class-mates. I'll never make a good engineer without an excellent command of languages."

Father examined me closely:

"Engineer? Is that your idea?"

"No, Evgeny," my mother broke in, "your older brothers' career is your career, too. Father and I will see to it that you never suffer any privations."

"And I, as you very well know, want the boys to choose

their own careers, as long as they make something worth while of themselves," father answered for me. "As for you, Evgeny, I am not going to coerce you either," he continued turning to me. "Remember one thing, I want you to become a real man so that you may be of service not only to yourself and your family, but to other people as well."

I pressed my father's hand gratefully.

"I am very happy I won't have to do anything against your will."

Now I had every chance to pave my own way, but first I had to finish secondary school.

With the pocket money father gave me, I hired a language tutor. Works of English, German and French classics in their respective languages appeared on my bookshelves. I had less and less need for dictionaries and soon caught up with the other pupils. I was graduated from secondary school with honours in the autumn of 1888.

"Now I know what brings one the greatest joy," I said to father in my moments of confidence. "It is the ability to set before oneself a goal, however small, but an independent goal, and strive hard to reach it."

"Let this be your constant rule, Evgeny," answered father. "When you grow up, your goals, too, will grow."

In my last year in secondary school I often wondered why some of my friends hesitated in choosing their future professions. As for me, my choice had been made: I would build bridges.

"But why just bridges?" my friends would ask me.

I answered the question willingly.

"There are two reasons. The first is personal. I like the exact sciences not for their own sake, but for the possibility of applying them in practice. Abstract numbers and formulae are not for me. It is quite different to see these

formulae and series of numbers embodied in engineering structures, and bridges represent one of the most interesting types of these structures."

"All right. And what's the other reason?" my friends wanted to know.

"Here it is. A great many railways are being built in Russia, my Country. Look at the map. Thousands of big and small rivers! By the time I am graduated from the institute Russia will need every competent bridge-builder. Do you understand now?"

"Yes, we do. You are lucky, Evgeny!"

I quite agreed. Lucky, indeed, is he who knows what he wants to achieve in life.

2. WITH THOUGHTS FOR MY COUNTRY

In the autumn of 1888 I enrolled in the school of civil engineering of the Dresden Polytechnical Institute. I was a tall, broad-shouldered and strong youth with a great deal of vigour and vitality.

In my very first year at the institute I worked out hard and fast rules of life and conduct and vowed never to break them. I did not divide the lectures into those of major and minor importance, never missed any and kept comprehensive notes. Many of the students neglected the graphic work ("boring, too much bother"), but I always did my best to fill all assignments strictly according to schedule. I would readily forego any pleasure in order to make an extra visit to a factory or some construction site. I worked with great enthusiasm in the students' engineering circle. I read avidly both at home and in the Dresden Public Library. I tried not to confine myself to the curriculum, but to learn from every possible source. Politely, but firmly I turned down all invitations to students' drinking bouts.

The scowling looks of some of my fellow-students failed to disconcert me. Soon I heard the following opinions of me:

"He is a crank... Obviously overcome by ennui and premature senility. Don't the German students enjoy life, though! Not to overwork in the freshman and sophomore years is one of God's own commandments."

I was no less surprised when I observed the German students. While living in France I had heard a lot about German accuracy and conscientiousness, but could find these virtues only in very few of them.

"How come?" I mused. "Stupid, scandalous duels elevated to valour... Drinking bouts and debauches till the wee hours of the morning, arrogant manners and Prussian cock-like pride in their 'corporate spirit.'"

And I made up my mind: "To hell with them; I am here to study and let these loafers drill holes in each other with their musical-comedy swords if they want to."

Coming back from my first student vacations I chanced to have a talk with one of these students. I told him I had spent my vacations in Russia where I had worked hard all summer and passed my examinations in the Novozybkov secondary school for a Russian matriculation certificate.

"Is that all you had to do? What was the use? Wasn't there any skirt to dangle after?"

I turned away in silence and walked off. There was no use explaining to this rake that my cherished aim was a Russian engineering diploma. For the time being I was forced to live and study abroad, but as soon as I was through I should go back home and to the German diploma I would try to add a Russian diploma.

I was proud of the title of Russian engineer beforehand, though all that I had been told about Russian science in Germany should have belittled this title in my eyes. If the German technical journals of the time were to

be believed it appeared that Russian science was in its ABC's, with Russian bridge-builders at least a hundred years behind those of Europe. In Russia engineering thought was in its infancy, they said. And if it chanced now and then to create something worth while in railway building, it was not Russian, not original, but borrowed. Russian bridge-builders were assigned the unenviable role of imitators. Similar irony could be discerned in the lectures of the Dresden professors. To listen to them the very railway tracks all but stopped at the German-Russian border.

As the years wore on I no longer took any of this for granted. True, extensive railway construction in Russia was launched later than in some other countries, but having begun later Russia soon made considerable headway.

It was from my father that I had first heard of the remarkable Russian engineer S. Kerbedz whom father knew very well because they had worked together. The Nikolayevsky draw-bridge over the Neva, built by Kerbedz in 1850, was not only one of the most remarkable and beautiful structures of the time, but also the first bridge of this type with cast-iron arches.

"And two years later," father told me, "in designing a bridge for the Warsaw Railway, Kerbedz, for the first time not only in Russia, but anywhere in Europe, used iron lattice trusses of a considerable span in the bridge over the Vistula at Dirmau."

Soon afterwards I learned of D. Zhuravsky and N. Belelyubsky. The bits of vague information I was able to gather at that time revealed that Zhuravsky was the first in the middle of the 19th century to lay a serious theoretical basis for the practice of railway bridge-building. He developed a scientific method of calculating trusses and brilliantly applied it in the construction of all the bridges on the Petersburg-Moscow Railway.

All I knew of Belelyubsky was that he had designed the Syzran railway girder bridge over the Volga. But that bridge alone staggered my imagination. Its thirteen spans with multi-web trusses were one-mile long. This outstanding engineering structure testified to the daring thought of its creator and the high level of his theoretical knowledge.

More than anything else I wanted to make personal acquaintance of people who might enrich my hazy knowledge of bridge-building in my motherland. But Russian engineers, especially bridge-builders, rarely made their appearance in Dresden. Quite unexpectedly a lucky chance brought me face to face with an invaluable person. V. Kurdyumov, Professor of the Petersburg Institute of Railways, happened to come to Dresden on personal business. The professor intended to get married in the Dresden Russian church. Having no acquaintances in the city save the bride's relatives he applied for best men to the "Russian Circle," where he was (I believe not unintentionally) referred to me. I agreed very readily, of course, to serve as best man to the Russian professor. To become closer acquainted with him I think I would have travelled a hundred miles then! I learned from my compatriots that Kurdyumov worked on a most important problem: investigation of the behaviour of soils under pressure of bridge piers and railway embankments. Kurdyumov's work "Resistance of Natural Foundations" had brought him renown in the world of Russian science.

At the risk of incurring the displeasure of the professor's young wife I invited myself to their house and began to torment the professor with all sorts of questions. I did not care if I appeared importunate; Kurdyumov must know, I thought, that such opportunities presented themselves rather infrequently to Russian students in Germany. Far from displeased, Kurdyumov helped to kindle my interest in our national science even more.

E. Paton as a student

Silently and afraid lest I miss a single word I listened to Kurdyumov's story of the grand construction of the Great Siberian Road, the uncommonly daring and fascinating problems and the incessant heroic struggle against the elemental forces. There's where I should be! Then Kurdyumov told me about his institute... I learned that Kerbedz, Zhuravsky, Beleiyubsky and Kurdyumov himself had been trained within its walls, that many famous men of science recalled with gratitude the years spent in its auditoria and laboratories.

"There's where you should study, my young friend!" said Kurdyumov in bidding me adieu. "It's all right though; get it over with here as soon as you can and come back to Russia. There's no end of work there now."

On my way home I mused over his words and firmly retained them ever since.

My last students' vacations I spent again in my mother's family estate in Byelorussia. Everything there was in a muddle and went to rack and ruin. Mother mortgaged and remortgaged the estate several years on end, but only incurred ever greater debts. In complete despair she would say to me over and over again:

"I am a weak woman, Evgeny, and I no longer have the strength for this eternal struggle. You ought to try and do something."

I made an honest attempt to help mother; I went to banks, consulted competent people, but all those intricate financial combinations, mortgages, title-deeds, computations of compound interest were too alien and incomprehensible to me. My attempts proved of no avail and I finally gave up.

"It is sad, indeed, that it may come under the hammer," I would say to mother, "but what can I do?"

My mind was occupied with something else. I showered the Russian Ministry of Railways with letters begging to be admitted to final examinations at the Petersburg In-

stitute of Railways. I knew that was "against the rules," but insisted that an exception be made for me because, as a son of a consul, I had to live and study abroad.

It was perfectly clear to me that my indifference to the state of affairs in our estate grieved mother. She accused me of levity. Couldn't I, at last, understand that she was not thinking of herself! Did she and father really need so much now that the children had grown up and were becoming self-dependent? She wanted me to inherit the estate free of debts and mortgages and was concerned only with my welfare and the welfare of my future family.

Silently and with tears in her eyes mother listened to my answers to all these lamentations and vexations.

"Believe me, mother, the most treasured inheritance parents can leave their children is a habit and love for their life's work. It is by far more valuable than any material goods. I seem to have this habit, consequently, you need not worry about me. And, frankly speaking, I have no use for the estate; it's only a nuisance and a lot of trouble." I tried to mollify my sharp words with a joke. "I can truly say, dear mother, that I'm very lucky."

Mother did not reply. She thought my impracticability in the affairs of life a great misfortune. She would complain to others about me:

"He is in love with his bridges and won't have anything else! What's to become of him? What does he expect, the naive boy? Love for work... But this is so little!"

Mother and I soon came to terms though, and she was no longer so discouraged about my future. Immediately upon graduation from the Dresden institute I was made several offers. One was at the institute where I was asked to take the position of assistant professor in the department of statics of structures and bridges. It held out the promise of a future professorship. I hesitated, somewhat frightened by the too rapid transition from the role of a

student to that of a teacher. But, reminded how successfully I substituted for a sick professor for a few weeks, I finally consented. The bureau for designing the new Dresden railway terminal offered me a position of designer. Father advised me to accept this position, too: one should never confine oneself to teaching alone. Father always favoured my choice of profession; hadn't this been also his profession in the past? Mother, too, relaxed and regained her composure; she even said her ideas of life had perhaps become outdated.

I felt very strong at that time; I thought there was no limit to my powers, that my strong young back could hold any load. I started working at the institute and soon felt quite comfortable in my new position. My participation in the designing of a large railway terminal offered an invaluable opportunity from the very outset to verify and consolidate by practice what I had learned at the student desk. In January 1895 I was charged with designing a highway bridge by one of the largest bridge-building plants—Gutehoffnungshütte.

I worked with great enthusiasm on my first design and was never ashamed to ask for advice. I made it a point to learn from everybody—old engineers, designers and experienced workers at the plant. I carefully observed everything new, searched for anything that might prove useful in practice and persistently kept in mind my one and principal idea—Petersburg and a Russian diploma. My Dresden acquaintances, who, apparently, considered me taciturn and reticent beyond my years, would hardly have believed I could dream. But I did dream! I dreamt fervently and in my imagination saw the distant boundless spaces of Russia, the endless threads of rails running to the horizon and the beautiful tracery bridges spanning the banks of deep and mighty Russian rivers. It was hard, very hard for me to be away from my motherland. How unhappy my life had begun!

About the time I had lost all hope of ever getting an answer from the Russian Ministry of Railways, the long-awaited letter finally came. Its first lines made me intensely happy, the subsequent lines nearly drove me to distraction.

The letter informed me that: the request of Mr. E. Paton could be granted as an exception, but on the condition that he deign to enroll in the senior year of the Petersburg Institute of Railways, pass the examinations in all subjects and make five graduation designs, otherwise the Ministry regretted, etc., etc.

I read the letter several times in utter amazement. What a preposterous and unfounded demand! But it was useless to protest or object... This was the second time in my life I had to make a crucial choice, to make a decision that would forever determine my future.

"Well! Is it to be Germany or Russia?"

Here in Dresden I was already known; here I was ensured rapid promotion, maybe a professorship. My "well-wishers" had been telling me that over and over again. They kept saying:

"Germany must not tempt a young engineer with opportunities for a career and the good things of life alone. Where else can one find so broad a field for scientific daring? Where else in Europe is there such an advanced school of bridge-building and such grand teachers for a beginner in engineering and pedagogy?"

These unbidden advisers would not say anything outright, they seemed to stand upon ceremony and spared my national self-esteem. But it was clear they hinted at the imaginary backwardness of my motherland in bridge-building, based on the legend they themselves had invented.

I could have answered them that any country would have been proud of Kerbedz, Zhuravsky and Belelyubsky, but I did not care to get myself involved in any arguments. "Let life itself be our judge," I thought.

It was something else that worried and agitated me. "Lose a year's time? Go to school again? Agree to all this after I myself had taught at the institute, designed a bridge and took part in the construction of a large railway terminal?"

I was longing for actual, useful work in my motherland and now I would again have to make student designs and study subjects which were never included in the curriculum of the German institute.

Here in Dresden I had a promising career, there in Petersburg—one more year of hard and strenuous student life, which is really worth three years, and, as yet, a very uncertain future.

All this is true enough, but then before me is Petersburg, Russia! Haven't I dreamt of it for so many years? Yes, this is worth any sacrifice. Father fully agreed with me.

And I made up my mind. Good-bye, Germany, there's nothing you can do to hold me back! My place is in Russia.

In August, 1895, I left for Petersburg.

3. RUSSIAN DIPLOMA

One more hurdle was cleared—a very high and very hard hurdle. I can hardly believe it myself; is it possible that only ten months ago I left Dresden and went home? Went for good?

The assembly hall of the Petersburg Institute of Railways... The solemn atmosphere of commencement exercises... Seated on a dais are venerable professors—the most prominent Russian bridge-builders. M. Gersevanov, President of the institute, has just finished his commencement speech addressed to us graduates. He is 66 years old, but under his pince-nez his eyes look young and full of life; he speaks with emotion. I look at his high forehead and his grey hair and try to imagine him as a

thirty-year-old man when he came to the Caucasus and began the construction of strategic highways.

Gersevanov gave twenty years of his life to the work he loved; for a quarter of a century he supervised the building of roads under incredibly complicated and dangerous conditions, fighting endless terrible landslides and overflows of unbridled mountain rivers. Daring thought of a builder and profound knowledge of a scientist were excellently combined in this persistent and whole-hearted person. Gersevanov's mountain roads won world renown for their durability.

"No, this is no arm-chair scientist," I thought. And when he called on us, "his new young comrades," to dare, to be keen and persistent, he was morally justified, for all his life had been a glaring example of this.

It was with a palpitating heart that I took the diploma and the silver insignia of a Russian engineer from Gersevanov's hands.

Once upon a time, nearly half a century ago, on the very same spot stood Zhuravsky, the future famous bridge-builder, and he, too, perhaps felt that his hands trembled with excitement. It was here, within these walls, that he had started his brilliant career in Russian science. Somewhat later Russia heard the name of another glorious alumnus of the institute—Belelyubsky. It was here that he had become professor at the age of 28; it was here that he created his magnificent and unique mechanical laboratory for the analysis of building materials; it was here that he headed a department.

For me all these men were beacons, whose light illumined my way and regulated my pace.

The solemn part of the exercises was followed by tumultuous mutual congratulations. In a few days or weeks, we—the happy graduates of today—would take off our modest student-jackets and don the impressive full-dress coats of railway-engineers.

L. Proskuryakov, famous bridge-builder and professor of the institute, firmly clasped my hand. His words reached me as though through a rainbowed mist:

"Your diploma bridge design, Mr. Paton, stands out among the others for its novelty. I enjoyed its defence in the Ministry's commission. I wish you the best of luck."

I am jubilant: I have been noted by Proskuryakov himself! That means something. I hardly know what I am saying; I utter something in gratitude, but feel my words are awkward, alien and trivial. I am too excited. Proskuryakov understands it and smiles. A few minutes before my hand was clasped as firmly by an old Dresden acquaintance—Professor Kurdyumov. He is very, very happy I had enough gumption and perseverance to realize my old dream. He always believed, even back in Dresden, we would soon meet in Petersburg. Whether he meant it or not, it was nice to hear it anyway...

Proskuryakov told me afterwards that on that memorable day he had spoken about me to F. Maximenko, professor of hydraulics and Inspector of the institute. It turned out that Maximenko had heard something about me from his assistant under whose supervision I made my diploma turbine design.

Both professors hardly suspected at the time what role they were soon destined to play in my life.

The year which ended with that solemn evening was of especial importance to me. I had always been known for my endurance and assiduity, but before graduation from the institute I had got the first taste of bromide and made personal acquaintance of nervous disorders. In eight months' time I had to prepare for examinations in twelve subjects and execute five serious graduation designs. It may not have been so hard if I had studied all these subjects in Dresden, but that was not the case; courses in steam-engines, water-turbines, locomotives, etc., were new to me. In one year I had to do the work that usually

required two to three years. I began with the design of a bridge, the most important of all diploma designs, because I had already designed bridges in Germany.

The design was ready on time. I abandoned the outdated analytical method of calculation, which was cumbersome and complicated, and employed the so-called influence lines method of calculation. I was very anxious to know what the old bridge-builders would say. However, both Proskuryakov and Nikolai (the latter had recently been appointed professor at the institute) thought highly of my work.

By January 1, 1896, the blue prints of a bridge with cantilever trusses were ready together with the other designs. Five designs in four months. Those were months I will never forget. I was usually one of the last to leave the draughting-room. It seemed strange to me that, while other students and I were nearly finished with our drawing, several students still discussed ways and means of beginning their work.

For the life of me I could not understand what they expected, nor what they were preparing themselves for. Wasn't there any number of good examples around them in Petersburg, at the very institute or in the history of Russian science? One felt like taking these loafers by the hand and bringing them at least to the museum of the institute. Yes, to put them before the model of the iron bridge built by Ivan Kulibin, and ask them to think through how this Russian genius, back in the beginning of the century, in 1801, worked on three different types of metal bridge and not only made several designs, but also worked out the technology of manufacturing the separate units and structures of a metal bridge, their assembly and installation.

To think that Kulibin never had the chance of studying at an institute, never attended lectures of first-class professors... Or, perhaps, invite these gentlemen to the

banks of the Neva, to the spot where I had stood many times and admired the wonderful creation of Kerbedz. Let them hear the story of a youth from a poor peasant family; the youth who was able brilliantly to complete his studies at the very same institute they were now finishing; the one who, by his enormous and strenuous work, rightfully earned the title of "Nestor of Russian engineers!"

But nobody wanted or asked for my advice and I kept my thoughts to myself. Now and then, as I came out of the draughting-room into the corridor for a little rest or exercise, I quite unintentionally listened to them.

The cynical frankness with which several of these gentlemen with sleek little moustaches expounded their plans for the future! One of them, fair-haired, with a haughty air and arrogant look, dreamt aloud of a profitable job in the administration of a railway, of the lucrative position of a chief of a railway division, of well-paying contracts. He hinted directly at an all-powerful relative with important connections. He was simply hypnotized by the impressive salaries and bonuses and was not interested in anything else. Another one, a fat boy with a stylish wedge-shaped beard and pince-nez on a string, was telling breathlessly somebody else's story about adroit road-builders who could "make money out of pure air." It was disgusting to hear these expatiations, but I knew it was high time for me to learn about the shady sides of life, life in the raw. I knew that once out of the institute I would inevitably encounter in my daily life not only honest and talented engineers, but money-grabbers as well.

The following method of money-making was cited as an example. During the construction of the Siberian railway one of these gentlemen contracted with the railway administration for the assembly and installation of several large bridges. The metal for the bridges was to be supplied by the railway. The terms of the contract included large forfeits to be paid to the contractor for deliveries

overdue. And it turned out that the steel mills were sometimes late shipping the metal. It was done on purpose. The responsible people were bribed by the contractor, and both parties made their "little" extra money...

Listening to such stories I mused over my future. My relatives, too, made hints that with their connections they could find me a "snug" and lucrative job. But what did this mean? To become a racketeer or at best take an easy job and get one promotion after another. No, this does not justify my efforts, this beaten path is not for me.

I knew that among the students at the institute—both the junior and senior divisions—there were many who shared my idea of the calling of a Russian engineer. They studied with stubborn persistence; together with me they were the last to leave the draughting-room and in the mornings they frequently came to the institute with eyes swollen with night home-work. One of these young men was in his fourth institute year. He was known to the entire institute for his enormous capacity for work and assiduity. A person with a big and clearly defined talent of a designer and an excellent memory, he did not rely on his abilities alone, but thoroughly studied every interesting book in his chosen field. His knowledge was firm and profound. The student longed to "get at everything himself." This was G. Peredery, afterwards an outstanding Russian bridge-builder and teacher of several generations of transport engineers.

I liked people of this stamp, people who loved work, who thirsted for knowledge and for whom life was not a parquet floor covered with rugs, but a hard-beaten and rocky road, and yet a road full of creative joys.

Now after graduation from the institute I could no longer ponder over the choice of my career; I had to make it. I wanted to live a full creative life rather than merely vegetate; I wanted to work and create something new,

try everything within my power. This meant I had to work from the ground up, start from the very beginning.

Even as a youth I had two roads open before me; I could choose either idleness or work. I chose work. There could be no turning off this road now.

4. LIFE'S FIRST LESSONS

My meeting with Professor Yasinsky, very well known at the time, made me take my final decision. The name of Yasinsky, a talented mathematician, was very popular in Petersburg; his lectures were always well attended. Everybody knew he was gravely ill; consumption was fast driving him to the grave. In damp weather he drove to his lectures in a closed carriage and was hardly ever allowed to leave home without rubbers or an umbrella. And this mortally sick man was possessed of indomitable energy and capacity for work. Mathematics alone did not satisfy him; the second half of Yasinsky's soul belonged to engineering. Yasinsky combined his teaching with work in the administration of the Nikolayevskaya Railway. His sensational dissertation was entitled "On the Longitudinal Curve." The insistent advices of his relatives and friends to take care of himself, not to burn himself out in work and confine himself merely to teaching, he turned off with a joke or left without response.

I thought this man a beautiful and noble example of how one should live on this earth. When Yasinsky offered me to work together with him on the railway, I consented without hesitation. I felt I had enough health and vigour for both and that next to a man like him I would acquire faith in myself.

That was the time when railways were being very rapidly built in Russia. More than 20,000 kilometres* of

* Metric measures used throughout the book. — *Tr.*

railway lines were laid in a period of ten years, 1890-1900. The steel threads of the Great Siberian Way stretched ever farther east. Work was being done simultaneously on many sections; large, multi-span iron and wooden bridges were being constructed over the rapid and wide Siberian rivers. The total length of the bridges was about 40 kilometres. Railway engineers and bridge-builders had to overcome enormous difficulties; life posed ever new and increasingly complicated problems before scientists and men of practice, and they invariably solved these problems. I envied these people passionately, with all my soul. The head of the Russian bridge-building school was doing tremendous work for the Siberian road. This was Belelyubsky, a man with inexhaustible energy, great initiative and profound theoretical knowledge; the man of whom I had already heard so much. Large-span bridges designed by him were being built over the Irtysh, the Uda, the Chulim and other rivers.

I was now being addressed as "colleague"; I designed iron rafters including flooring for railway shops of an original system, proposed by Professor Yasinsky. I knew, of course, that rafters and flooring were also needed, but I was dissatisfied, though I never told anybody about it. That work alone was not enough... Bridges! that was what I wanted to build; that was the technical field in which I longed to work and show my worth.

As though he had overheard my dreams Proskuryakov helped me take the first step towards their realization. He asked me to design an overpass for the Moscow Station of the Yaroslavl Railway. This was already something more substantial, it offered wide opportunities for independent pursuit.

I gave myself heart and soul to the work on this design. The hands of the clock in the technical department of the railway moved very slowly. All I wanted was to get back home to my draughting-board and calcula-

tions. Both in the office and on my way home I only thought of one thing—my design. A great deal depended on the success or failure of my modest beginning. Too much was at stake, indeed, for it was not only others who were testing me—it was a self-test.

Within a few weeks, full of meditations and searches, the work was finished. Before me lay the design of an overpass with a lower chord drive, continuous three-span trusses on intermediate piers in the shape of swinging columns with ball and socket joints. I reread the descriptive part, critically examined the drawings of my "first-born" and judged myself severely, very severely. I was under the impression that I had coped with the assignment rather well. The roadway was designed in an original manner without longitudinal, or cross-beams and consisted of continuous riveted corrugated flooring. This reduced to a minimum the construction height of the overpass and the height of the embankments on the approaches. The only thing that worried me was the attitude the Engineering Council of the Ministry of Railways might take towards my swinging columns and corrugated flooring. Both were technical novelties at the time. Won't the experts centre fire on them?

Much to my happiness everything turned out satisfactory. The design caused no objections, either as a whole or in any of its details, and was approved. But the technical idea underlying it was not yet fully realized. Similar swinging columns were designed several years later for an overpass of one of Petersburg's railways which was from time to time travelled by imperial trains. During the examination of the design in the same Engineering Council one of its members took exception to it.

"Such columns cannot be put up with," he said pointblank. "A heavily loaded cart might run into them and knock a column out of its socket."

The other members of the Council agreed with the super-cautious speaker. Just think of it, the Russian emperor himself travelled this road! As a result it was decided on clumsy piers of rectangular section without joints. It was only several years later that I took revenge. The columns of my design found wide application in the construction of the Moscow Circuit Railway. This incident firmly stuck in my memory for it taught me that it was difficult for anything new to win recognition!

My first works attracted attention. I began to receive private orders for designing city and highway bridges from city and district councils. This may not be quite so interesting as designing large railway bridges, but it provides experience and will be of some benefit to me, I decided, and became utterly engrossed in my designs. I worked very fast because of the rational designing methods I employed.

The work of some of my venerable colleagues simply bewildered me. I once asked my fellow-engineers in the railway administration:

"Where did some of the old engineers get the habit of spending so much time on useless painstaking calculations of figures which should be based on practical considerations. Why, for example, spend weeks on uniform and unnecessary calculations of trusses with continuous walls?"

I was excited and did not understand I was regarded as a child, who suddenly discovered some shady and unknown sides of life.

"Look here, my lad, you better stop fighting windmills. We have long since given up this business," was their answer. "And get this straight, your speed may only make enemies. Those who rouse your indignation believe that by working too fast they would only undermine the confidence in their competence and cut down on their fees. Get it?"

It was all clear to me now. The more tables, calculations and formulae in the design, the more one could "grab" from one's client.

Soon afterwards I made several attempts to approach the Ministry of Railways. I was always received with frozen smiles, affably and courteously, but was asked to call the next day or the day after. Then the "next day" unnoticeably changed to "sometime" and "in time we may find something." I understood and discontinued my visits. After all I did not come to ask for alms! I wanted to design and build large, beautiful and strong railway bridges, to continue the work of my outstanding teachers and predecessors, as well as those who were following in their footsteps, and here they were getting rid of me as if I were a poor, importunate relative. From my father I inherited love for independence and pride which were incompatible with fawning upon the authorities, and I certainly did not care to be humiliated before the Ministry officials.

But why were they so afraid in the Ministry of admitting young people to the "Engineering Olympus"? The answer to this question came to me when I made closer acquaintance with the morals and manners of the so-called higher ministerial spheres.

At that time a small group of old engineers in the Ministry enjoyed the full monopoly of designing many bridges for roads under construction. The "working-out" of designs was organized in grand style. The group had an assortment of ready-made designs of bridges with different spans and offered them to various roads. I could hardly understand such people. What sense did the engineers see, what interest did they find in this standard work?

This attitude to work I considered humiliating for the designing-engineers themselves.

I fully concurred with Proskuryakov who boldly disregarded all traditions in designing the largest bridge

over the Yenisei in 1896 and employed a new method of calculating the trusses with the aid of influence lines. This enabled him to execute the design on new, simpler and more scientific principles. The trusses proposed by Proskuryakov were noted for their greater height than had theretofore been customary, as well as longer panels; the design permitted of more efficient calculation and was simpler in manufacture, while the building of the bridge required much less metal.

There was a special reason why these innovations agitated me so much. Wasn't it the same method of calculating trusses with the aid of influence lines I had employed in my diploma bridge design? But in my case everything remained on paper, whereas Proskuryakov was the first man in Russia who dared introduce in practice a new system of trusses and a new method of calculation which was simple, practicable and at the same time most scientific.[1]

I was extremely envious of my teacher, but meanwhile continued designing highway and city bridges. It apparently appealed to my clients that I tried to economize metal, expedite the construction and lend beauty and originality to the bridges. I received many orders. For a young engineer, only a year after graduation from the institute, these orders also signified success. Work on these bridges brought me certain satisfaction, gave experience and in some measure advanced me and provided material security.

But why should only half or even a quarter of my pow-

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[1] Bridges with the Yenisei type trusses have won recognition and Proskuryakov subsequently designed large railway bridges which were built over the Oka, near Kashira and Murom, over the Volga, near Yaroslavl, Simbirsk and Kazan, over the Niemen and the Western Bug, etc. The last important creation of my teacher (he died in 1926) was the arched bridge over the Volchye Girlo of the Dnieper at Kichkas near the present Dnieprbges Dam.

ers be engaged? Why should great daring and bold creative deeds of some people live happily side by side with the indifference and selfishness of others? To these tormenting questions I could find no answer. At that time I lived in the small and secluded world of my narrow professional interests; the vast and complicated life of Russia, full of social struggle, contradictions and sharp contrasts moved past me leaving me somewhere on the side, and I was unable to understand the reasons for my first vague doubts and disappointments.

5. IN THE PROFESSORIAL CHAIR

In the spring of 1897, the second educational establishment in the country for the training of transport engineers was opened in Moscow. It was the Railway Engineering School. The school's system of training was rather unusual—a three-year theoretical course followed by two years of continuous practice after which students were granted diplomas. The school was headed by Professor F. Maximenko, and the Inspector, i.e., the assistant principal in charge of curricula and programmes, was Proskuryakov.

I was soon convinced that Proskuryakov had not forgotten me. In his own name and on behalf of Maximenko he asked me to move to the second Russian capital. He promised me interesting pedagogical work at the school.

It did not take me long to make up my mind. Proskuryakov was calling me and that was sufficient. With new hopes I went to Moscow. I was only 27 years old, just a little older than my future students, but I decided that in addition to imparting real knowledge to them I would also try to inculcate in them my ideas on the calling of a Russian engineer.

Maximenko and Proskuryakov received me very cordially. I laid down no conditions save one: to give me as much work as possible. This, apparently, won Maximenko's favour. He appreciated industry in people no less than ability. Proskuryakov saw in me a person who held the same views as he. He was twelve years older than I, but treated me as an equal. All three of us found that we matched each other to a tee.

I was offered simultaneously two positions: assistant director of the mechanical laboratory and observing professor of third-year studies. In addition I was to give students practical instruction in structural mechanics. I could not have wished for anything better myself, since what I was offered included everything. Meanwhile second- and third-year classes had not yet begun and I had nothing to do. Just loafing or whiling the time away was against my grain, and when I was asked to take the post of manager of the newly organized technical department of the Moscow-Yaroslavl-Arkhangelsk Railway I readily consented.

At that time work on the railway was going full speed, first on the division from Yaroslavl to Vologda and later to Arkhangelsk. This was the main attraction to me since to work on a railway under construction had always been my cherished desire.

The department I was to work in was being newly organized. It was being set up under very unfavourable conditions and staffed with only three engineers. One of them, a very old and decrepit man, was not easy to stimulate. The second, a middle-aged man, occupied himself chiefly with administrative affairs. The third member of the staff, a rather incompetent young engineer, was working on a special assignment of the Ministry of Railways, making endless and useless calculations for reports on steam-heating and ventilation already in operation in the offices of the railway administration.

It was not long before I understood that the department was to play second fiddle. Neither I personally, nor the department as a whole ever got any orders for designing large structures; I learned later that they had been intercepted by furnishers of stereotyped designs similar to those of Petersburg. All the department received were orders for designing various small structures along the tracks and at stations. I had to execute them myself and keep a couple of dozen technicians and draughtsmen hard at work. True, this work gave me a chance to study the different railway services.

The administration employees trembled before the management and the owner (the railway was privately-owned), tried to ingratiate themselves and imitate the higher-ups only not to incur their displeasure. There were also bribetakers among them. I made no attempt to put them on the straight and narrow. Nor could I remain indifferent when engineers, in searching a route for a particular division of railway, agreed for a large sum to alter the direction of the route by making a detour if that was to somebody's advantage. These gentlemen feasted with contractors in restaurants where they pulled their deals. Of course, there were also many honest and decent engineers and employees on the railway, but these had to take a back seat for they were given to understand that in case of interference on their part they would find themselves out of jobs.

Nikolai, one of the well-known Russian bridge-building engineers, was to me a model of scrupulous honesty. Upon graduation from the Petersburg Institute of Railways he started working on railway construction and in the central administration of state railways under the Ministry of Railways. From 1892 on Nikolai had been member of the Engineering Council of the Ministry and the chief expert on construction of railways and large bridges. Someone else might have used his high position

for personal gain, but not so Nikolai. I shall cite a single example to show the honesty of this wonderful man and teacher of a generation of Russian bridge-builders.

One day the Engineering Council of the Ministry of Railways approved the blue prints for fishplates for one of the divisions of the Siberian railway. A big batch of the fishplates made from these blue prints turned out worthless. The holes in the rails and those in the fishplates did not fit. The treasury was losing a lot of money. As soon as Nikolai found out about it, he decided he was also to blame as a member of the Council, figured out his share of the damages and at the next sitting of the Council offered to pay it in securities. His offer caused general perplexity; the Council hardly persuaded him to take his securities back.

I was very happy, when work in the school required all my time, and resigned from my position in the railway administration.

I began teaching in a Russian educational establishment in 1899 and continued it for forty years. The first course I taught was in structural mechanics; a year later I started teaching a course in iron and wooden bridges, at the same time supervising the work of designing them. It makes me happy to think that I had trained dozens of expert bridge-builders. Many of my former pupils and pupils of my pupils now head engineering departments, design and build large bridges, write textbooks and conduct research work.

I never sought cheap popularity among my students, nor tried to overawe them. I only wanted my students to learn from my lectures what they could not get out of textbooks. The latter was particularly important since the textbooks of the time were out of date.

I always began my courses by telling the students frankly:

"What I want of you is your serious attitude. I'm warning you I shall make no allowances at the exami-

nations. I have no use for idlers or lily-white hands. Those who are only after a diploma and a pretty insignia don't belong here."

Not all students liked my asperity, of course. Those who were rather lazy felt ill at ease. Most of the students, however, appreciated my harshness. I made it clear to them that they would have to work hard, but that it would be to their own benefit.

After one of my first lectures I was approached by a student with sharp and attentive eyes and firmly pressed lips on his oblong face. He wanted my permission to say a few words for himself and for his comrades. Several of his fellow-students were close by.

"Dear Mr. Paton," said the student with a quaver in his voice and pulling at his little moustache with embarrassment, "we can judge by your lectures that you work much harder on them than we do. This sets a good example for us. We have pledged to work twice as hard and want you to be very strict with us at the examinations."

We shook hands cordially. I did not suspect at the time that the student, who spoke so sincerely, would subsequently become an outstanding engineer and scientist, designer of Dnieproges and the general scheme for electrifying Central Asia, one of the creators of the Baikal-Amur Railway. This student was I. Alexandrov.

Still holding Alexandrov's hand I addressed the whole group:

"Work hard while at school and it will pay well in later life. I was a student myself but recently and I know now how true this is. Work is the basis of all our life, my friends. I want you to be industrious and devoted to science; this will make you real masters of life. Not masters of other people, but masters of all the secrets of engineering, science and nature."

It was then that my friendship with the students began,

a stern, even severe, friendship without the external manifestation of mutual feelings and sympathies, but a friendship that had left an imprint on all of us for many years to come.

Alexandrov was not mistaken; I was much more exacting with myself than even with the students. I worked late into the night in preparing for my lectures. I searched in magazines, designs and dissertations for anything that might be of benefit to my students. Teaching, unlike any other profession, perhaps, requires stubborn and persistent work, for in order to teach others the teacher himself must study untiringly as long as he lives.

6. DISSERTATION FOR MY DOCTORATE. TEXTBOOKS ON BRIDGES

I had a favourite penholder, a simple, ordinary penholder made of a piece of birch-wood. I used this penholder in writing my first two articles and my diploma paper. Then a playful idea occurred to me: "Let this ordinary penholder be my personal relic and may all particularly important events and dates in my life be connected with it."

I decided to hide it in a drawer and to use it again only when I start writing my dissertation.

A dissertation for the degree of adjunct of the Institute of Railways entitled one to a professorship. But that was not all. It was not the first time I had thought about my dissertation. Some dissertations are nothing but conscientious compilations of well-known truths, though perhaps ably stated and presented. They are usually shelved and no one ever takes any more interest in them. The result is rather incongruous: they seem to be written only for the sake of a professorship, since they are of no use either to science or to practice.

I confided my thoughts to the head of the school.

"I shouldn't like to harp on ABC's or rehash commonplaces, Mr. Maximenko. A dissertation, in my opinion, must propound advanced ideas that do not as yet enjoy general recognition, and, what is even more important, contribute something new and essential to practice."

"Certainly," said Maximenko. "One can judge by the very subject of the dissertation whether the writer will ever make a scientist or is doing it all for the sake of a professorship. You're on the right track, my dear man."

His words encouraged me. I always felt at ease with him and could talk frankly about anything. I liked this even-tempered, modest and quiet person, who was the merrier the more he worked.

As soon as Maximenko saw I was very earnest about my dissertation he arranged my working hours so that I had more time for myself. I appreciated it, but never thanked him aloud because he disliked any outward show of gratitude.

I ruminated over my dissertation day in and day out. It was born of life itself, of the struggle which began at the time, of the conflict between progressive thought and outdated, obsolete conceptions and outlooks which could not be prevailed over and ousted from practice, save in open battle. I decided to direct the essence of my work against the statically indeterminable bridge-trusses of the two- and three-web systems which were in wide use at the time. One of their chief defects was the great additional stress due to the rigidity of their joints.

I checked myself time and again and decided I had chosen my subject well.

"Your proofs and conclusions must be particularly convincing," Maximenko would say to me. "The theoretical basis is certainly very important, but you must have facts."

"Naturally. But let us take the experience of our

Proskuryakov, who had already shown in practice, on real bridges, the advantages of statically determinable systems. What if his opponents have not changed their minds? In my dissertation I shall try to combine the results of practice with scientific argumentation."

"Well, I hope you pin your opponents to the mat," Maximenko jested. "How soon will you start?"

"In the summer, during my vacations. I have no other time."

The following summer I left Moscow for the country. I knew I would have no time for rest, but that was unimportant. Out of town, away from all other cares, I would be able to devote myself completely to my dissertation.

Pyotr Kamentsev, one of my most capable and most promising students, lived in the country together with me. He agreed to help me with some of my calculations in the belief they would prove useful to him.

I spared no efforts that summer. Step by step I investigated and compared the magnitudes of additional stresses resulting from the rigidity of joints in the trusses of various systems. I gathered extensive and convincing material, which I had made on a number of trusses of different types, but kept searching for new proofs.

"Even the blind can see you're right," Kamentsev, to whom I confided my thoughts and inferences, would say to me. "It's about time you had some sleep. Look at yourself in the mirror."

"No, I must go on, my boy," I would answer. "The old does not easily yield to the new. It must be helped along, so to speak. As to sleep... I don't think I'll have any time for that. The new academic year is before us."

And I would go back to work again.

The calculation of all continuous trusses is based on the assumption that the members, which converge in the joints, can revolve on an imaginary swivel. As it is, these joints have rigid, riveted connections. The members

cannot possibly revolve and because of that additional stresses arise in the joints. It was my task to prove that there were lesser stresses in the simple truss systems than in the two- and three-web systems.

The information, which I was able to find in books, was meagre and irrelevant. In order to compare the outdated types of trusses with the new and as yet hardly accepted types I had to do a lot of calculating. For this I used the lines of influence. Unlike the analytical method this method possessed greater distinctness and clarity. I employed it for the first time in my diploma design at the Petersburg Institute. It was also used by Proskuryakov in designing the bridge over the Yenisei and some other Siberian bridges.

At last my dissertation was finished.

"I'm afraid you'll make some real enemies, Mr. Paton," said Kamentsev after reading my dissertation.

"Why, you know the old Russian saying: 'if afraid of wolves don't venture into the woods.' Especially since the wolves are somewhat decrepit, and though they still bite hard, they can be subdued anyway."

In 1900 my dissertation was published. I was very anxious to see which of my adversaries would be the first to open fire. But they, apparently, evaded an open encounter, or perhaps simply hoped that a dissertation of a young engineer and a beginner in teaching would not alter anything and was not dangerous.

After one of the lectures I said to Kamentsev:

"Well, I'm about to attack. Wonder what will come of it."

"Victory by all means," the student exclaimed fervently. "All my friends wish you good luck."

In the summer of 1901 I mounted the dais in the assembly hall of the Petersburg Institute of Railways. I was just past 31; only five years previously I had presented my diploma design in the same place.

The assembly hall was packed; seated at the table were the most eminent scientists in impressive uniforms with sparkling decorations. I tried not to notice the pomp and circumstance in order not to let anything distract me. I was, certainly, excited. Many of those present had read my dissertation and knew that one, who had only recently been a student, dared to contest the theory and practice, which reputable old scientists would not part with.

I tried to regain my composure. I wanted to show everybody, even by my outward appearance, my intonation and gestures, that I knew I was right.

I began to speak and felt my voice grow firmer. Now and then I looked away from my paper and darted a glance at the audience. Everybody seemed to listen attentively.

Finally I came to my last page.

The Council of the institute unanimously conferred on me the degree of adjunct. Soon afterwards I was appointed associate professor of bridge-building and supervisor of bridge-designing at the Moscow School, which had already become very near and dear to me. I was very happy since none of my adversaries dared accept battle. But even that was not the main point. The most important thing was that the advocates of the old-system trusses, who hoped that my dissertation would pass unnoticed and like many others would be shelved, were disappointed. My work had not been in vain. The two-web system was struck a crushing blow. Many had to admit that these outdated and uneconomical trusses were very much inferior to trusses of other systems and from then on they were never built on Russian railways.

It was then that I began to understand that scientific work in the field of engineering was of any value and could be justified only if it made a direct contribution to practice, illumined new trends and helped to smash and discard the old and the useless.

I realized that not only scientific papers, but also textbooks should be similarly purposeful and concrete. In order that Russian bridge-building have competent and daring engineers the textbooks used by the students must also be up-to-date.

Incidentally, the textbooks were far from satisfactory.

I had deep respect for Nikolai, my teacher and one of my examiners at my doctorate examination. His fine books on the theory of bridge calculations and permissible stresses for bridges were well known. But my respect for Nikolai's personality and his knowledge as theoretician and practical bridge-builder in no way obscured the fact that his textbooks were in many respects outdated. His descriptive course of bridge-construction was written for practical technicians, but was unfit for students. His three-volume course of bridge-designing—the only one in Russia—had another very substantial defect: its part on calculations was encumbered with unnecessary material. Instead of presenting only the best method of calculation in each individual problem, the textbook gave the students various, frequently outdated, methods, which left the students to their own devices. Besides, all calculations were purely analytical. The lines of influence, in the advantage of which I had had ample opportunity to convince myself, were only mentioned in passing, at the end of the course.

It was clear that such textbooks would not do. The lectures and textbooks did not tally.

I discussed my perplexity with Proskuryakov. While listening to me he nodded sympathetically. When I was through he took a book from his desk and handed it to me.

"I encountered the same difficulties," he said, "and here is how I tried to surmount them. Look through this little book, it may suggest something to you."

I looked at the cover and saw Proskuryakov's name on it. This was a textbook on strength of materials and

statics, which he had recently written. I recalled I had heard Proskuryakov complain that good textbooks on structural mechanics were lacking.

"I see," I managed to say, "but why is it so small?"

"Look through it at your leisure, we'll talk about it some other time," he answered.

I read the book the very same evening and was amazed. It was concise, there was nothing superfluous; all the necessary information was clear and comprehensible. The style was really enviable, but I felt that to write so concise and comprehensible a book required a lot of hard work.

Several days later I saw Proskuryakov again.

"I won't say much, but I believe this is precisely what textbooks should be like. May I ask you, though, if such conciseness will not make it hard for the students to comprehend the material?"

"I expected this question," Proskuryakov answered calmly. "But I want to teach the students to think rather than learn by rote. Away with all that is superfluous or casual. Let the book contain only that which is really necessary. What do you say?"

Yes, that was the type of textbook I had dreamt of. That was how I had tried to plan my lectures. As a matter of fact many professors and instructors at the school now endeavoured to select only what was most important and essential to their teaching.

At the chemistry lectures, delivered by I. Kablukov (subsequently an eminent Russian scientist) the students were surprised how simple the formulae had become, which had formerly seemed so complicated. The favourite of the students, S. Chapligin, who was only 30 years old at the time, made them penetrate into such depth of mathematics, which had formerly been utterly beyond their comprehension. He was a living confirmation, as it were, of the well-known aphorism: "He who thinks clearly speaks clearly."

Chapligin had been a pupil of the famous mathematician N. Zhukovsky. On the request of Chapligin Zhukovsky frequently came to the school, usually for especially important conferences and commencement exercises. Zhukovsky was teaching theoretical mechanics at the university; he went to each of his lectures as if it were the first one in his life and was never satisfied unless perfectly sure the students had understood everything. He advised his young colleagues at the school to observe similar rules. I always tried to be closer to Zhukovsky, when he spoke to the graduates, and avidly listened to his brief, abrupt remarks. For all his great fame he was a plain and modest person. It was evident that he liked to talk to the graduates on so solemn and important a day in their life as graduation. But despite the elation and festive atmosphere the first thing Zhukovsky always wanted to know was whether the young engineers had been sufficiently well trained for independent work, whether or not they were afraid of responsibility.

I came to the conclusion that Proskuryakov had given me the right direction. It was no use waiting for someone to write model textbooks. I had best try something myself. I wondered if I could possibly do it. I wanted to write a book that would give the future bridge-builders the essential and most important information. But this was to be a voluminous work—a four-volume girder-system bridge-building course. It would have to be four volumes, and for the beginning, for the nearest future, I would need at least the first two volumes.

It was with these ideas that I started working on my textbook. By that time I had been appointed Inspector of the school. Maximenko believed that my principal task was to write textbooks and took the greater part of my responsibilities upon himself. And still I had less spare time than I needed. I taught myself to get up at six o'clock in the morning so that I might work through the

morning hours when one can think clearly and write with ease. I've kept this habit ever since.

Had I saved the rough copies of my first textbooks, they would show how hard I had worked on them. I wrote and rewrote several times on separate slips of paper each paragraph, each table or formula of calculations before I felt it was fit to be put in the manuscript. I spent days on end thinking over each page, searching for the clearest and most laconic formulations, and made numerous trips in order to get first-hand information of the most interesting bridges.

I watched the bridges in operation, under stress; I compared their merits and defects, the beauty of their trusses and their architectural composition. I studied bridges at home and abroad (in Germany, Austria-Hungary, France and Switzerland) and critically compared my personal impressions with what was written about them in old textbooks. I brought numerous photographs and drawings to Moscow, but one of the most important acquisitions was my own conclusions and appraisals, which did not always coincide with what I could find in literature.

I worked on my books for three years and published the first and second volumes of my course of iron bridge-building and calculations of wooden, iron and stone bridges. I sent to the printer's no less than 400 typewritten pages annually. The books found a good market and were sold as soon as they made their appearance.

The discrepancy between the lectures and textbooks disappeared. I noted with satisfaction that the students were acquiring more knowledge. But those, who expected that I would now be less exacting, were mistaken. On the contrary, I now exacted more than ever from my students and much to everybody's surprise introduced a new grading system by adding half-grades. Those, who did not get

a satisfactory grade, were "warned" and could be sure that a re-examination would only be so much the harder.

The students, who were a little weaker in spirit, complained that I flunked them. But this reputation failed to disconcert me, for I knew they would only be thankful to me later. I was right; many years later I received friendly letters from eminent scientists and outstanding engineers with expressions of gratitude for my former strictness.

The *Course in Bridge-Building* had brought me some renown among the bridge-builders. But the popularity of the textbooks meant even more to me. I received letters from all parts of the country, showing that not only students, but also bridge-builders, engineers with many years' experience, found something useful in them.

One day I received a letter from Kiev. The Kiev Polytechnical Institute offered me the newly organized department of bridge-building. The administration informed me it was cognizant of my textbooks and the bridges I had designed in recent years.

Under the impression of the letter I recalled unintentionally the history of each of those bridges. I designed two highway bridges over the Zusha and the Petinsky overpass in Kharkov in co-operation with Kamentsev, who had been graduated from the school and was now working with our common teacher Proskuryakov on two arch bridges for the Moscow Circuit Railway. I thought that within a few years Kamentsev would himself become a professor and would probably replace me in the Moscow School. (My conjectures were right. 44 years later I received Professor A. Otreshko's two scientific volumes entitled *Construction Designs*. The author had been Kamentsev's pupil and wrote he was very happy to continue to the best of his ability the great work, begun by his teacher's teacher.)

I designed the railway bridge over the Matira together

with Ivan Alexandrov. This talented young man, son of an ordinary physician's assistant, was already making great progress. I never doubted he had a fine future ahead of him. Prokofyev, another of my graduates and one of my most capable pupils, had also made himself heard. At that time he was finishing the construction of a large multi-span railway bridge over the Amu-Darya. The Bryansk plant entrusted him with the supervision of all the work. To think that only two years previously he had studied my textbooks and blushed and paled before the examiners. I did not have to worry about this pupil.

I also recalled my bridge over the Gorny Tikich, the bridge over the Obsha in Bely, the designs for the Metropol Hotel roofing and many other things. All this somehow merged in my mind into a single whole—my own work on all these designs, the work of my pupils and assistants, who had now become independent, talented and honest engineers, and the thankful letters from my former pupils, who were still studying my textbooks. I was so happy in the knowledge that my Moscow years proved so fruitful.

And now I faced a new dilemma: either to stay or give up the Moscow School for other very important work, to which I would have to devote myself without reserve. It goes without saying that I was both excited and flattered by the letter from Kiev, for that was an obvious recognition I had won at the age of 34. But at the same time I was somewhat abashed and even a bit frightened by the scope of the new work. It was no easy task to organize and head a department of bridge-building in one of the largest educational establishments, but then what great opportunities it offered!

I felt sorry to leave the school with many of its teachers and students, and, above all, with that good old soul—Maximenko, and my own teacher Proskuryakov. Maximenko might think I was ungrateful for all his solicitude and

support. I anxiously awaited the forthcoming conversation with him. But Maximenko knew what attracted me in Kiev and neither reproached me nor kept me from it. We parted cordially, as good friends. Maximenko hoped I wouldn't forget the good Moscow traditions in my new place.

Making ready for my departure I thought: the institute was young and so was I, which was a good omen.

And, as is always the case, when one makes a sharp turn in life, I was a bit alarmed and flustered.

7. IN KIEV

I came to the Kiev Polytechnical Institute in the summer of 1904 and worked there for 30 years.

From the very first days I was amazed at the customs and manners of the civil-engineering department, for they differed fundamentally from what I had been accustomed to in Moscow.

Its curriculum was in a state of real chaos. It was based on the subject system, and there were graduating students, who had not as yet passed their examinations in first-year subjects. The incongruity and harm of this system were obvious to me and I immediately took exception to it. However, my objections were ignored.

Soon I was elected dean of the department. This vested me with certain authority and I decided to take advantage of it. But as soon as I tried to reorganize the curriculum and the order of examinations I was checked. They would not allow me to touch the subject system. I insisted, but was continually ignored. I then tried to change things singlehanded, but that was altogether against their grain. They looked askance at me and some of the professors hinted I had better do as the Romans while in Rome, or I could easily make enemies.

I had to step back for a time, since my authority proved insufficient and I was unable to convince the administration. I noticed that my excessive energy and assertiveness irritated many of my colleagues.

The dean, who preceded me, was a man of a different stamp and apparently suited the professors and administration more than I did. Weak-willed and lazy, he preferred not to interfere very much in anything and especially not to quarrel or strain his relations with anybody. The students openly said that the work of the department was supervised by the dean's very enterprising wife, while the dean himself was but a pawn in her hands. In order to win any favours from the dean the students often solicited them directly from this omnipotent dame.

I was equally surprised at the speculative nature of the teaching. The engineering department was so poor in visual aids that the students were given only oral instruction without any objective demonstrations. I began organizing an engineering museum and a study-room of bridges with a special library. This required several years, but there were palpable results even in the first academic year. Soon some students and teachers volunteered to help me. We obtained models, ordered instruments and collected books wherever we could. I brought quite a number of my own books to the library. For the first time now the department had instruments for the testing of trusses, models of bridge parts and a sizeable collection of photographs and lantern-slides. I made extensive use of them at my lectures. Instead of acquiring abstract ideas the students could now make rather complicated experiments and get a visual idea of what had formerly been a vague abstraction.

It all appears normal and self-understood now, but at that time many of my colleagues looked at such innovations as useless fancies. My activities were regarded as a desire to stand out among others and attract atten-

tion to myself. My only desire, however, was to impart solid knowledge to the students and make them full-fledged engineers. Here in Kiev like in Moscow I was therefore attentive to every student in his studies and very hard at the examinations. I gave no leeway to idlers or dodgers, but never let the honest and serious students out of my sight and, noticing a "spark" in anyone, tried to fan it into a flame. Alexei Tolchin was one of these capable, I might say talented, students. He was noted for his rare truthfulness, the straightforwardness with which he defended his views, and his ideal honesty. I liked these traits very much and we became good friends. When I subsequently started working on the 3rd and 4th volumes of my course in *Iron Bridges* he helped me materially in preparing them for print. Tolchin's premature death—he died very young—was a great blow to me.

One year after I had been elected dean I asked to be relieved of this post. I had done all I could in that short time, but now I preferred to devote all my spare time to writing textbooks and designing bridges. My request had met with no particular objections. Apparently, my independence and obstinacy were a bit too much for the administration and my more conservative colleagues.

It was 1905, the year of revolutionary upheavals in the country. The formidable student disturbances throughout Russia also took in the Kiev Polytechnical Institute. The meetings and gatherings seethed and boiled. I made it my rule to keep out of them. I firmly decided that politics and social life in general "simply did not concern" me and did my best to stay within the narrow shell of my official and domestic interests. Lectures, textbooks, bridges—that was my business, whereas all those bitter political controversies, student strikes and demonstrations, revolutionary demands and the cynical appeals of some very reactionary professors to "teach these trouble-makers a lesson" had nothing to do with me. I could not fathom

all those passions, nor did I really care to; I wanted both the "lefts" and the "rights" to leave me alone. I lived the secluded life of a typical pre-revolutionary professor; I knew only my bridges and was sure nobody and nothing would ever drive me out of my circle of special technical problems. I believed my indifference to "politics" to be very firm and would certainly never have thought that times might change and the events would force me to give up my artificial and far-fetched position of "neutrality" in social life.

A highway bridge over the Kura was built in Tiflis after my design. I contracted for this work with the Tiflis City Council. When the design was ready neither I nor my client liked it. Then I offered the following solution. I should sign no contract and would execute another design, but this time only with one span instead of the three formerly intended spans, i.e., without the two intermediate piers. This idea promised substantial economy in the construction. I declared I would design the bridge on my own risk and that the City Council would have to pay me only if the design were accepted. We made a gentlemanly agreement. Then, together with a student who was working on his diploma, I designed a bridge in which I replaced the three spans with cantilever trusses with a single span, which had original arches. The design was approved and we were paid our fee.

Two of the highway bridges designed by me were built over the Ros in Korsun and Zvenigorodka. Both are interesting for their driveway, which is made of a reinforced concrete plate with three longitudinal ribs supported by iron cross-beams with a continuous wall.

The work of designing the Kiev foot-bridge made me very happy. The bridge is located at the end of Petrovskaya Alley and is well known to all inhabitants of Kiev. The extension of Petrovskaya Alley was hindered by a remaining slope of the hilly bank of the Dnieper. At first it

was proposed to drill a tunnel through it, which did not appeal to me. This wonderful corner of Kiev could have been decorated with a light and beautiful bridge. The bridge would have looked uncommonly attractive against the background of the boundless Dnieper spaces and the magnificent Kiev parks. I offered to make a deep excavation in the slope and span it with a light foot-bridge with crescent-shaped open-work trusses.

This idea carried an appeal and was approved. The bridge was being built under unusual conditions, before the excavation of the slope. The surface of the slope was cut off parallel with the contour of the truss' lower chord and small cages were placed on the ground. The lower chords and other members of the bridge were assembled on these cages. When the trusses were riveted and lowered on to the concrete piles built beforehand, the excavation was started under the bridge. This was a rare method of assembling a bridge.

My new textbooks were being published nearly every year; they included the 3rd and 4th volumes of the course in iron bridges, a comprehensive course in wooden bridges and other textbooks and manuals. I worked as painstakingly on these books as I did on my first texts. For example, when I had to deal with the question of complex grooves in the junctions of round logs for the construction of wooden bridges I made, with the aid of several students, models of the joints with such grooves, photographed them and ordered the clichés to be put into the textbook of wooden bridges. I wanted every section of the book to be clear and concrete.

Outwardly everything went well in my life. It seemed I had nothing to complain of. I headed a department; the bridges, designed by me, were being built; my books were being printed and were becoming ever more popular and I was also well off financially. The Petersburg officials gave me promotions from time to time, and at the age of 40

I had the rank of councillor of state (rank in pre-revolutionary civil service). My origin and position in society opened for me the doors of the "select homes" of Kiev. What else was there to wish for? My late mother would have been very happy at my successes. If one were to see the situation through her eyes, everything was really fine.

But that was not actually the case. Ever since my adolescence I had been in the habit of looking at life critically and judging it independently. And now in my adulthood I could not and would not deceive myself. I felt increasingly tired with each passing month, with each passing year. I checked up on myself and realized my fatigue was not only physical, due to excessive overwork over a period of many years, but it was also fatigue of my soul. This made me observe life more closely and sum up my experiences. This was long and hard work, which went on deep inside me and was invisible even to my closest friends. It was this work that had led me to a decision, which was incomprehensible and unexpected to all.

I made myself take a detached view of my life.

How did I live? The philistine, colourless life of many of my colleagues—my neighbours at the institute apartment house—was against my grain. My wife and I disliked visiting them and increasingly avoided their invitations. I crawled deeper and deeper into my shell. I could not stand the petty-bourgeois gossip at a card or dinner table in the director's or some professor's home; I hated the frivolous pastime, the tattling about friends, the envy of the successful and the mockery of the unfortunate. Despite our common official interests I felt I was a stranger in this society.

I made friendships very slowly and with difficulty. My lectures were something else; at my lectures I would flare up, become fascinated and speak simply and with ease. In company I was a different man; I would retire

into myself, frown and keep silent. I knew people explained this by my unsociable character, my reserved disposition; I knew behind my back they called me a white raven, a crank who was not interested in drinking or cards. As the years wore on this estrangement did not diminish, but, on the contrary, kept growing and I could not, nor did I really want to lessen or relax it. It all occurred in spite of me and I did not worry very much about it.

The traditional banquets, held on the anniversaries of the Petersburg Institute of Railways, produced a dual impression on me. These events were attended by the graduates of the Institute who lived in Kiev and the nearby towns. Sitting at the table I listened attentively to the boisterous conversation.

When the wine loosened the tongues, those, who had reasons for it, boasted with ecstasy of imposing bank accounts, carriages, profitable marriages and fortunate stock-exchange transactions. Career, comforts, money, new rungs in the official ladder—those were the ideals of such people. All about us inculcated in them these base and mercenary interests.

I knew, of course, not all of them were the same. Some of them spoke of their daring technical plans, of new designs for bridges and railway terminals, of the agonies and joys of creative effort and of their day-to-day work. It made them happy that their school-mates worked with zest and lived with fervour. But alas! they did not count, they were not in the upper crust, they were not in favour with the "powers that be."

"Is it possible that time goes on but nothing changes?" I asked myself sorrowfully. "Is life standing still? We've learned to build bridges by new methods, but our ideas have not altered." It seemed to me time had stopped forever.

And I came to a sad conclusion: "I'm 43 years old; by hard work I've managed to get some place; I may have

done better than many other people, but I've lived like a hermit midst the dead metal bridge-constructions. I've given myself heart and soul to my work, but all I have got in return are material goods. I've been a stranger not only among most of my friends, but also among my closest relatives. My brothers have become landlords, well-to-do people, big officials. They never understood or appreciated my aspirations, and we've long since come to the parting of our ways."

At the age of 43, in the prime of my life, I felt utterly lonely and very tired, almost like an old man. To be sure, I had many pupils and I hoped they thought well of me. But they, too, had their own life, their own interests. It was solitude and futility. Was it worth going on?

Later I recalled with amazement the state of mind I had lived in: having lived half my life I had lost all interest in it; I simply broke down.

I did not have to worry about my old age. I had managed to save some money from the sale of my textbooks; the savings together with the interest and the pension should have been enough to live on for the rest of my days. I thought it might be well to move somewhere south, to the sea-shore and buy a country-home with a garden.

During my 1913 Christmas vacations I went to the Crimea, where I selected a small country-house on the seaboard. It was just the thing I had dreamt of. Upon my return to Kiev I pictured to myself my cosy corner in the summer with the gentle lapping of the waves in good weather and the roar of the tides on stormy days, my quiet, painstaking work in the garden and on the vegetable patch, the long trips to the mountains, the peace and quiet and the bright summer skies over my head. A playful thought involuntarily flashed through my mind: What a surprise this will be to my colleagues! A professor of bridge-building in the role of gardener. I couldn't help laughing when I thought of the long faces

E. Paton as professor of the Kiev Polytechnical Institute.
1905

they would pull. Let them say what they will; let them think whatever they wish. I've had enough!

That evening, when I made up my mind, I took a pen and paper and made ready to write. Unintentionally I fixed my eyes on the penholder. It was the penholder that revived so many happy memories. The diploma, my first books, the dissertation... And there was the finale which I had chosen myself. I was breaking sharply with everything. That was the sum-total of all my past, which had been filled with work, agitation, searches, offences, successes and failures, hopes, disappointments and struggle. All that was now receding into the past. And what irony there was in that simple relic—the birch penholder, which, at one time, had been so dear to my heart. Both my penholder and I were retiring.

I dipped my pen into the ink and started writing.

I was writing my request for retirement to the President of the Kiev Polytechnical Institute.

Part Two

THE WIDE AND OPEN

1. STORMY DAYS

WHEN THE FIRST WORLD WAR broke out I was in Nice, taking treatments and resting after a severe illness—pneumonia and nervous complications. During the winter I recovered completely, felt quite good and was dreadfully homesick. My sister, who had come to France together with me, was very fond of Nice, where we had been born; she loved its beautiful nature and the mild sea climate and tried to persuade me to stay there forever. This idea had never appealed to me, and now, when Russia was at war, living away from my motherland was completely out of question.

I longed to go home, but the direct route to Russia via Germany had been severed by the war.

Only in February 1915 I took the long way around to Russia through Italy, Bulgaria and Rumania. I had to stay a few days in Rome. I strolled about the ancient city, examined the ruins of the Coliseum and stood enchanted under the famous dome of St. Peter's Cathedral. The height of the dome, the enormous inner dimensions of the cathedral and the lighting made a strong impression on me.

I admired the beautiful Italian capital and its ancient monuments, but my thoughts and feelings were else-

where... Russia was in trouble and I was anxious to get back there and help my country as best I could.

In Naples I visited the excavations of Pompeii and Herculaneum; at the opera I marvelled at the ardour with which Italians responded to music. From Naples I went by boat to Sorrento where I enjoyed the fragrant air, the surprising quiet and the wild beauty of its steep, rocky shores. The Adriatic and the Corinth Canal were at last left behind; then followed Salonika, Sofia and Bucharest. In Rumania I felt I was quite near home.

I returned to Kiev, to the same Polytechnical Institute, and tried to rid myself of the unpleasant, bitter after-taste which lingered on after my voluntary resignation. The war had deranged the regular schedule and I had to teach primarily students of the last two school-years since their graduation was being speeded up.

My colleagues and friends were elated during that first stage of the war. I, personally, hardly understood the causes of modern wars. I reasoned quite primitively: "Wilhelm attacked us—we have to defend ourselves."

Of course, I remembered well the 1905 war with Japan and the anguish I had suffered at the time. The war was fought somewhere, very far away, and countless train-loads of soldiers were driven to the Far East. General Kuropatkin was reporting victories from the front and we believed them at first. But when it was no longer possible to hide the bad news, the generals and the government called for patience and faith in victory. Then we learned that the government was incapable of prosecuting the war, the country was not prepared for it and the soldiers had to attack the Japanese positions with barely any arms. There was a striking contrast between the lying and boastful newspaper articles and the terrible reality.

Ten years had elapsed, but it was still very hard to forget the ignominy of Tsushima, the vile treachery of

the Port-Arthur generals, the treason and corruption of the military leadership. In 1904-1905 the army fought heroically for Russia, but the headquarters and ministries traded in their lives and blood. I was ashamed and hurt for my powerful and at the same time helpless motherland.

In 1915 I did not think the experience of 1905 could recur. The sad experience of the Russian-Japanese War should have taught our rulers a great deal. They could not help learning. At any rate every Russian must do his best now to help his country. And I searched for ways and means to do my share.

Until then no one in our country had thought very much about designing prefabricated bridges which ordinarily replace the ones blown up. We were very much in need of them. At that time we only had several outdated types of such bridges designed by the French engineer Eiffel (famous for his tower in Paris), a few prefabricated small span-structures, designed by a Russian engineer, about 12 metres, for narrow-gauge railways, and some broad-gauge span-structures of the Rot Wagner system, captured by our troops in the war.

The situation was disastrous. I did not know this branch of bridge-building, nor had there been any previous domestic experience. I had to start actually from ABC. I began to read foreign literature on the subject, but could find very little help in it.

There remained but one alternative: not to let anything disconcert me, to design the bridges myself and, according to my old rule, to resort to the aid of my favourite associates—the graduating students. I could foresee the difficulties, but what of it, our task was so much the more honourable.

As early as 1916 I started together with student Seidel to design a 140-foot broad-gauge railway, prefabricated span-structure with a lower chord drive. Its trusses

had a span of 44.5 metres. The design was completed in a very short time and we forwarded it without any remuneration to the Administration of the South-Western Railways. Our "first-born" proved so successful that the administration immediately ordered seven span-structures of this type and soon installed them on several railways where the bridges had been blown up.

In 1917 the Kiev Department of Railways began building seven strategic wooden bridges over the Dnieper. I found out that my former pupil, engineer Prokofyev, had a Department order for designing wooden Gay-system trusses for the navigable spans of these bridges. I believed steel trusses to be more reliable and cheaper and offered my services to the chief of the Department. I did not ask him to dismiss Prokofyev, but wished to enter my design in a way of creative emulation. Since there was very little time, graduating student Damsky and I worked very hard and completed our design in two weeks—an unprecedented short time. And though Prokofyev was still working on his design, the advantages of the steel span-structure were so obvious that the Department decided to accept our design.

I was also charged with placing the orders for the manufacture of these seven span-structures, which necessitated my going first to the Bryansk plant in Yekaterinoslav and then to the Yuzovka plant in the Donets Basin.

All through the years of the First World War I repeatedly enlisted the services of graduating students in designing wooden bridges including a large trestle on the left bank of the Dnieper near Kiev, which served as an approach to the Podol Railway bridge. My students worked with me on designing and later in testing this trestle. Our "Pioneer" pile-drivers proved very effective. We sent our drawings, notes and "weight specifications" directly to the builders of roads near the front. I went

there many times myself to inspect the bridges under construction and to give needed advice.

I devoted myself wholly to my work but could not help noticing what was going on about me. It was real torture to realize our industry was so weak that many designs of steel bridges remained on paper. Russia smelted too little metal, and our railways frequently had to do without metal structures. Those, who came from the front, told us that batteries at the front-lines often kept silent for lack of shells, that the soldiers had little ammunition and in many cases there was one rifle to every two or three soldiers.

Unpleasant thoughts involuntarily went through my mind: "There is not much difference from 1905. What have our rulers been doing?" I kept asking myself.

To place one of the orders for bridges I had to go to Yuzovka in the Donets Basin. The steel mill there was owned by the Englishman Hughes; the other enterprises belonged to British, French or Belgian capital. Going through Yuzovka I witnessed terrible poverty. The workers lived in dug-outs or in huts made of boxes and boards, but the house of the plant's superintendent (an Englishman) was notable for its luxury. The dinner, I was treated to, probably cost more than several workers' monthly wages. I was beginning to understand how the soldiers at the front felt, when they cursed the war and those who made profits on it while leaving them without ammunition.

I saw our industry was owned mainly by foreign capital not only in the Donets Basin, but everywhere.

From that time to the very end of the war my friends and I grew more and more disappointed; we were doing all we could to help win the war, but at the front there was disorganization and frequent defeats, and we doubted the tsar and the government could do anything to put things right.

I repeat, towards the end of the war even the people in my circle were dispirited and their patriotic intoxication was dispelled. Many were well aware the army was very poorly equipped, the tsar was surrounded by dullards, embezzlers of state property, German agents and spies, and was himself incapable and alien to the people. Suffice it to recall the treason of the tsar's minister of war—Sukhomlinov. The industry, which was in large measure rented out to foreigners, was so weak it could not supply the army. My faith in the government wavered even more.

Was there any use in my efforts and the efforts of many honest people if everything about us was going to rack and ruin?

The February and to a greater extent the October Revolution perplexed me. I thought complete chaos would inevitably follow and Russia, surrounded by enemies, would be lost forever. The bitterness of the civil war that ensued and the cruel terror of all manner of interventionists perturbed me even more. It seemed to me it was the end of Russia and the enemies would tear the country to pieces. Fortunately, I was mistaken. I saw that, headed by the Communists, the peoples of former tsarist Russia were able to drive out all those, who tried to restore the power of the landlords and capitalists. This alone gave me greater faith in the people I had known so little until then.

The government changed 16 times in Kiev, but neither my family nor I would leave the city. I waited to resume work.

I wasn't at all sure at the time the Bolsheviks would accomplish anything worth while, but they were certainly dispensing with Russia's enemies and to my mind that was a tremendous success.

I was sure the people would soon need my knowledge for the restoration of the bridges after the terrible devas-

tation. Work for my motherland had been the chief aim of all of my preceding life. True, I could see very well the local representatives of the victorious Soviet Government were rather suspicious of people like me. That was natural. To be frank, I was also somewhat sceptical of the new government. The aims and policies of the Bolsheviks were to a great extent incomprehensible to me. One thing was clear to me—bourgeois Europe would not give the Bolsheviks any credits or loans.

"Where will the Bolsheviks get the means to raise Russia from the ruins?" I wondered at the time and could find no answer.

Heroism was enough to beat the enemy, but building requires money, and plenty of money at that.

Anyhow, the country was in a bad state and I could not stay idle. In these trying circumstances I considered idleness, and especially sabotage, a crime.

2. DESTRUCTION OF CHAIN-BRIDGE

I shall never forget that day. A sound wave of tremendous force hit and shook the window-panes of my institute apartment on Brest-Litovsk Highway. The second blast shook the dishes in the sideboard and some unseen hand threw all the doors wide open.

I pushed my chair aside and ran out on the balcony. My wife Natalya ran after me. I grasped the railing and fixed my gaze on the Dnieper. Deafening explosions roared over Kiev. I looked at my wife and saw she understood everything.

A distant pillar of smoke sprang up somewhere over the river and spread across the sky in an ominous bluish-black cloud, obscuring the bright June afternoon.

"The chain-bridge," I said in a cheerless voice, still looking at the horizon. "How did they dare?"

"It's impossible," said my wife shrugging her shoulders with a shiver.

"Impossible? Haven't they thrown six other bridges into the Dnieper? What do they care if this is the only bridge of its kind in Europe? They are literally burning the bridges behind them."

"Let's go to the children, they are probably scared," my wife said gently.

She apparently wanted to distract me from my sorrowful thoughts. I did not answer and my wife went in softly shutting the door.

There were no more explosions. Near by, the bridge, known the world over for its beauty and originality, was sinking into its water grave in the Dnieper. Lonely stone piers above the river was all that remained of the bridge.

I left the house and walked down to the highway.

The Polish whiteguards. . . In the last few days I went several times to the Brest-Litovsk Highway to take a look at them. The uhlans and legionnaires, who but recently looked like opera actors, were now a disorderly ragged mob fleeing for dear life.

Hiding behind fences, boys jeered and sneered at them.

"Hey, there, 'gentlemen,' which one of you is Pilsudski?"

It had long since become a habit with the boys to hiss and jibe at the conquerors in foreign uniforms of all colours and styles. The wearers of the various smart uniforms always declared they had come to stay and then were hardly able to get away alive.

"Remember me to Petlyura![1]"

"Regards to the Keiser!" hooted the ragamuffins.

Deafening catcalls and taunts followed the dismounted and no longer arrogant uhlans.

"Now these 'heroes' are fleeing, looking round mali-

[1] Ukrainian bourgeois nationalist.—*Tr.*

ciously and scared but what outrages they have perpetrated before leaving," I thought to myself. Many crimes had been committed in the streets of Kiev in the past three years, numerous innocent people had been hacked by sabres, countless passers-by had been trampled by horses for only a contumacious look. All those criminals had had the same ignominious fate. On the same highway I saw the fleeing hordes of Petlyura's cut-throats in Caucasian fur-caps, the Denikin hangmen in British uniforms and the Eichhorn German punitive expeditions. They had all come to "save" Russia and the Ukraine, but the people they had come to "save" drove them unceremoniously out."

Rumbling over the cobble-stone highway and raising a good deal of dust the Polish transport moved past me. "Well," I said to myself with a sigh of relief, "these must be the last 'savers.' The Denikinites[1] and Polish whiteguards were "saving" Russia with English and French money, the Petlyura-ites—with German money. They were all in dread of the mysterious Bolsheviks. And even some of my institute colleagues, 'true Russian people,' as they called themselves, deserted to the whiteguard generals in the south."

"Who are these Bolsheviks anyway?" I wondered on my way home through the park. "They are Russians like myself. Then why were some of my colleagues so scared? Was it because they had lost all their privileges and bank accounts? Well, I've also lost my securities and all other valuables. But like many other educated old Russians I never threw myself into the arms of all sorts of Denikins or other pretenders to the Russian throne. I waited for all this line of governments to come to an end, and there I am now—all the foreign 'savers' together

[1] Henchmen of the whiteguard general Denikin.—*Tr.*

with the Denikins and Kolchaks[1] have been driven out of Kiev and out of the rest of Russia. And who did it? The Bolsheviks."

"What's going on there?" my wife greeted me anxiously. "You had better stay at home at times like this."

"They're on the run," I answered abruptly.

It was several minutes before I broke the silence.

"Do you know, Natalya, how long the bridge had been there? Nearly 65 years. The iron links of its chains had been brought by ships from England to Odessa and then carted by Choomaks[2] to Kiev."

My wife looked at me in amazement.

"Carted? You must be joking."

"Not at all. There were no railways then. And now it only took them a few minutes..." My wife gently put her hand on my shoulder.

"I know what you are thinking of now."

I raised my eyes questioningly.

"You want to rebuild the Chain-Bridge."

"You've guessed it. But my wish alone won't do. We need metal, money and plants to do this troublesome work. Our people are still wearing bast-shoes and there isn't even enough bread to go around."

A roar of nearby artillery fire from somewhere on the other side of the Dnieper reached our ears.

"And blood is still flowing," my wife added sadly. "Who wants your bridges now?"

"You know, Natasha, I haven't spoken to a single Bolshevik yet, nor have I seen any of their leaders. But if they are in earnest about ruling Russia, they won't be able to do without us who can build bridges and want to build them. The times of the Choomaks are gone forever."

[1] Admiral, commander of whiteguard troops in Siberia and the Far East during the Civil War in Russia.—*Tr.*

[2] Ukrainian ox-cart drivers.—*Tr.*

My wife smiled unexpectedly. I caught her glance. Our two boys—three-year-old Volodya and two-year-old Borya—were busy putting up some complicated structure with two sets of building-blocks.

"A fine example for the adults," I whispered to my wife, trying not to scare off the children who were anxiously watching their high tower.

3. MATTERS OF GREAT URGENCY

Regular studies at the Polytechnical Institute were resumed.

Entirely new people appeared midst the student-body in 1920-21; people in greatcoats, who had only yesterday braved death, who, rifle or sabre in hand, fought for the victory of the Soviets, now came to the institute with an enormous thirst for knowledge.

Some of them came directly from railway freight depots where they earned their living by loading and unloading timber, others boiled at nights some sort of fantastic soap, which had all the outer attributes of the real article, but for some reason wouldn't form a lather and hence did not sell. Still others manufactured cigarette-lighters or wooden shoes. All in all this boisterous and cheerful student-tribe lived a hard life, frequently going hungry and smoking very cheap tobacco, but never losing heart. Many of the old students—mama's sonny-boys—deserted, and only those, who had strong roots, stayed on. Turning up their collars, breathing on their ice-cold fingers and stamping their feet to get warm, the students worked in the draughting-room for weeks on end, but never showed any signs of discontent. They were happy to be working on designs of real bridges, rather than on abstract themes, because those designs were impatiently awaited on the Dnieper, the Pripyat,

the Desna and on all the other rivers of south-western Ukraine; they therefore took their hardships in stride.

Side by side with these young people during the hard times I, too, somehow forgot my troubles and could not think of my cold flat, of the fact that a pound of millet was worth its weight in gold and that at home we had learned to slice our bread without ever losing a single crumb of it.

It was a joy to me to realize that my students and I did not hide in our corners and had not lost our keen interest in life. So much the more did I detest the people who made me think of wood-lice.

One day, walking up the institute staircase, I met an old professor. My colleague looked ironically at the thick briefcase in my hands.

"The thicker the briefcase, the more rations, hey?" he said with a venomous smile.

"Meaning what?" I frowned.

"I hear you're on the rolls as consultant in two Soviet institutions?"

"On the rolls? Some people may be on the rolls hunting for rations, My Dear Sir, but we are working. Yes, my good man, working, restoring and building bridges. May I pass, please?"

Never moving an inch the venomous professor burst out laughing. Real mockery sounded in his voice.

"Can't you see they're bluffing? It's high time you understood the Bolsheviks are only a rolling stone on the Russian soil. Just think of that impudent young man who tried to teach us collectivism by ordering all fences at the institute torn down. Just think of him. And you intend to work with such people?!"

"He's long since been dismissed," I snapped out and pushed this brazen-face aside. "As to bridges, they do intend to build them and are already building them in

all seriousness. In this work I am ready to go along with them. As to you, you are your own boss."

I was already reaching the top landing when I heard his last caustic remark:

"Incidentally, maybe you'd like to restore the Chain-Bridge as well?"

I said nothing at the time, but on recalling this quarrel later I felt the pain of the blow, which had been aimed at the most vulnerable spot.

Hundreds of bridges in the country had been destroyed by the war.

I had already been working for over two years in institutions engaged in restoring the railway and highway bridges in the Ukraine; I advised the designing and building of the bridges over the Dnieper, the Desna and the Pripyat, and took part in the discussions of all technical problems connected with restoration of the Darnitsa and Podol bridge-spans, dynamited by the Polish whiteguards. It was certainly not the pursuit of rations that had brought me to Soviet institutions.

The Civil War damaged our railways more than did the World War. The interventionists and whiteguards barbarously demolished and destroyed the bridges leaving the young Soviet Republic a crippled transport. Our railways were in dire need of prefabricated long-span bridges with spans of up to 88 metres for broad-gauge lines. I knew we couldn't even think of putting our industry and agriculture in order without first restoring our transport. And when the People's Commissariat of Railways announced an international contest for a design of a prefabricated span-bridge 30 to 88 metres long with piers built of truss members, I immediately decided to take part in it.

The universality and wide range of the spans considerably complicated the design, but I was no longer a novice and made up my mind to work in spite of all diffi-

culties. I asked two recently graduated engineers—Labzenko and Starovoitenko—to take part in the contest. We argued and wrangled, but finally agreed on the most suitable system of trusses. We disregarded the fact that I was a teacher and they were my pupils, and fought for our opinions on an equal footing carefully considering all pros and cons. This did not protract our work; on the contrary, it speeded it up since it helped us avoid possible errors.

The finished design, consisting of many complicated drawings, calculation and descriptive notes, was handed in due time and we awaited the results. We were extremely happy, especially my young associates, when the results were made known.

There had been ten different designs in all; two or three of them (I do not remember exactly) had been sent in by foreign bridge-building concerns. The jury awarded no first prize, our design winning the second prize.

The People's Commissariat of Railways charged me with preparing various designs for installing the sectional span-bridges: a design for pendent assembly, several versions of a design for assembly on the banks with the subsequent rolling onto the bridge-spans. This time again my assistants were graduating students, among whom Narets was particularly notable.

Kamentsev, my old pupil, of whom I have already made mention, played an active part in the examination of these designs at the Central Railway Administration. (Incidentally, this pupil of mine developed into an eminent bridge-building engineer and a talented teacher. In 1952 I had the happy opportunity of congratulating him on the fiftieth anniversary of his scientific endeavours and on his seventieth birthday, which were celebrated in Moscow.)

The People's Commissariat of Railways gave preference to the design for cantilever erection. In 1922, when

all the assembly members were ready at the Nikolayev Ship-Building Yards, a commission arrived to inspect the span-structure and the assembly of several of its panels.

The trial cantilever erection was found quite satisfactory and the works delivered the complete span-structure to the client. Special classes were regularly conducted on one of the bridge-building sites to teach the workers and engineers the methods of cantilever erection. Soon afterwards the Commissariat ordered a few more span-structures of our design.

I finished my work on bridges of this type in 1922 with an interesting and original design for several prefabricated small-span highway bridges to be built of members weighing no more than 1.5 tons. I made this design with the assistance of three graduating students —Marants brothers and Marinichenko. The distinguishing features of the assignment were the low weight of the members, and the assembly and bridging, which were to take no more than three hours.

The required speed perplexed us at first; we suspected some error in the text of the assignment. We soon learned, however, there had been no mistakes and such speed had simply never been heard of before. I planned to design two versions of a bridge and set to work with my assistants. The span-structure offered no particular difficulties. It was much harder to swing the structure, assembled on the bank, by 90° and then roll the bridge onto the piers, but we surmounted these difficulties and planned the job to be done in exactly three hours. Both types of our bridges were accepted and we were awarded prizes.

In those years I spent a great deal of time and effort on designing numerous prefabricated bridges, but I am happy to say now my work was not in vain. At least four of the types of prefabricated bridges, designed by us, took firm root in bridge-building practice and have stood the test of time.

In designing bridges I nearly always enlisted the aid of my graduating students. They did the actual work while I made suggestions and step by step supervised the work of my young associates. They worked with the fervour and enthusiasm of youth and acquired precious experience in designing. I changed my assistants and co-authors for every design, and the supervision of the designs gave me therefore a lot of trouble and took a lot of my time. And still I loved to work with young people. My love for the young people did not prevent me from exacting efficiency and discipline from them. My associates must have cursed me time and again for the endless changes they had to make in their designs on my demand. But later, out of the institute, many of them realized they had acquired useful skills; I often heard them say that afterwards.

4. WHAT KIND OF NEW BRIDGE FOR KIEV?

Though my graduating students and I were very busy at that time, we never, for a single day, gave up our cherished dream of reconstructing the Kiev Chain-Bridge. It was an interesting and fascinating task.

The Kiev Highway Chain-Bridge over the Dnieper had been built in 1854 by Vignolle, a British engineer. Four large and two small bays were spanned by continuous chains which supported the cross-beams of the drive. That was the only bridge in the world with six-span continuous chains.

The Polish whiteguards blew these chains up only in one spot, after which all four large spans crashed to the bottom of the river. They must have been proud of their outrage, because eye-witnesses told me later they had photographed the four-span structure as it was sinking in the Dnieper.

As soon as normal life was restored in the Soviet Ukraine, after the expulsion of the last interventionists, the question of building at least a temporary crossing over the Dnieper on the site of the Chain-Bridge came up for consideration. Various versions were proposed. Under my supervision several graduating students of the Polytechnical Institute elaborated various drafts for spanning the bays of the former Chain-Bridge. We wanted to ascertain whether we could do with the remaining stone piers alone or would have to build temporary wooden braces. We did this work of our own accord in the form of students' diploma designs. These designs were examined at the Department of the south-western highways where I worked as consultant at the time.

We found that the construction of an iron bridge on the stone piers of the Chain-Bridge without additional intermediate wooden braces would cost only 25-30 per cent more, but that it would have decisive advantages for shipping, for timber rafting, for the passing of the drifting ice, and that it would make the bridge itself stronger.

As long as the problem was to be solved along these lines it occurred to us to reconstruct the bridge as it was before its destruction, i.e., make it a chain-bridge, and use the materials which we were to salvage from the water.

I had the same idea at first. A draft design of a narrower chain-bridge with a lighter load-capacity had been worked out according to my scheme as early as the summer of 1920, immediately after the old bridge had been destroyed. We planned to use only half the number of chains of the former bridge. Three more designs were offered in the subsequent years—in 1921-22. The idea of reconstructing the bridge by using the old chains was tempting, but we had to give it up just the same. All those designs had been rejected. Moreover, I myself

seriously opposed the idea, which at first appeared so attractive.

What were the reasons?

First of all there was the question of metal needed for the building of the bridge. The country was still metal-poor. Only one blast-furnace—the Yenakievo—was in operation in the South; several more were added later, but we could hardly hope to get the necessary grades of steel for the Chain-Bridge. The country had other important and urgent needs. Everybody understood that. On walking into the draughting-room of the institute I often observed the anxious and questioning eyes of the students. They all knew that I never let a month pass without seeing the "higher-ups" and nagging them about the bridge.

"What if we are working in vain? What if nobody cares for our designs?" I asked them, but I was reassured, encouraged and insistently advised to go on with the work.

Coming back to the institute after these visits and meeting the questioning gaze of the students I silently turned away and thought to myself:

"Aren't my pupils beginning to lose faith? Doesn't this bridge seem to them an obsession of a stubborn professor? To think that only recently a pound of nails cost millions of rubles and now we would need thousands of tons of steel. . ."

Those who wanted to rebuild the Chain-Bridge in its former shape asserted we did have metal; they said it was on the bottom of the Dnieper and all we had to do was to salvage it.

But that time they had only been able to raise some 750 tons of steel; its greater part—more than 2,200 tons—was still under water.

I realized that salvaging the steel would require hard work and a lot of money. The task was further complicated by the fact that the submerged parts of the bridge were not a single rigid system, which could have been

raised as a whole. The metal would have had to be cut under water and only then be extricated. The caprices of the river, the drifting ice and the freshets could have dragged the work out for more than a year.

Last but not least there was no certainty that the undertaking held out any promise. We knew that despite considerable expenses and hard preliminary work the attempts to salvage even the rigid trusses from the Volga and the Amu-Darya failed.

In a word, the entire venture appeared more than risky. The economic side, too, had to be considered. The work of raising and unriveting iron is in itself very costly. Divers had examined the submerged iron and their findings were far from comforting. The greater part of the iron was deformed and was no longer fit for the work. Suffice it to say, the material of the rigid trusses could be considered only one-third fit and then only if the bridge were reconstructed in its former shape.

It was therefore clear to me that with all that waste the cost of the remaining useful part of the iron would have been too high.

Nor was that all; we figured out that the job would have taken at least 7-8 months more if we added the time needed to build the bridge to the time required for salvaging the iron.

Not one of the reconstruction organizations of the People's Commissariat of Railways had sufficiently strong lifters to work simultaneously on several spans, which meant we would have had to work successively—span by span, while the raising and disjointing of each span would have required at least 2.5 months. Hence the conclusion: we would not have been able to finish the job in one building season.

A special Department was in charge of highways and bridges in the Ukraine. It was also responsible for the for-

mer Chain-Bridge. I had seen Shcherbina, the superintendent of this Department, on several occasions. During one of his visits to Kiev in 1923, Shcherbina asked me to come and see him. His face was imperturbably calm, but I thought I saw some merry sparks in his eyes. He looked me straight in the eye.

"If I get it right, Comrade Paton, you resolutely oppose reconstruction of the Chain-Bridge in its former shape?"

"Most implacably! And I believe my reasons are well grounded."

"Quite right. The Department also feels there is no point in counting on the submerged iron. It just won't do."

I nodded silently.

"Hm. And the metal situation is still bad," continued Shcherbina. "We are a bit richer, but the preference is for railway bridges."

I shrugged my shoulders. Why did he have to call me and give me new hope? I myself designed railway bridges at the time and knew very well they were the first to get the metal.

"And yet, it occurs to me, you'll soon have to start on the bridge design," Shcherbina smiled slyly. "Only. . ."

"Have we got permission to build the bridge?" I asked and jumped up without listening to the rest.

"Only," Shcherbina continued unperturbed, "we won't get any new metal anyway. We can't get it. The trick is to find it ourselves. Keep your seat."

But I had already lost my composure.

"Look here," I said at last, "you and I don't manufacture metal, you know."

"Alas. . . But we can make use of something and, I believe, find a good way out." He handed me several sheets of paper. "Look these over and let me know what you think of it."

As I have already mentioned, seven wooden strategic bridges with iron navigable bays had been built on the Dnieper during the First World War. After the war the bridges were dismantled. The papers, which I was now reading, were an inventory of I-beams that had remained after the dismantling. The inventory named several points on the banks of the Dnieper near and below Kiev, where these beams were to be found.

Shcherbina looked at me expectantly. My silence seemed to worry him.

"Well, what's your word, Comrade Paton?"

"It's an interesting idea, I think. As far as I know big, permanent bridges have never yet been built of material like that. Interesting, very interesting... And tempting. Only it must be carefully thought out whether it's possible and how it should be done."

The Superintendent of the Department realized the problem was very serious.

"All right, you don't have to give me your answer right away. Think it over, acquire faith, so to speak, and then come again. I should like you to support the idea and not delay it. How about it?"

I consented, of course.

I was quite perturbed when I came out in the street. Passers-by had to turn off my way to avoid colliding with me. I walked along immersed in thought and seeing nothing about me. Our persistent work had not been in vain then! I recalled how one of the professors at the institute ridiculed me quite recently for believing I could reconstruct the bridges. "It's a bluff," this very unpleasant fellow had said then. No, Gentlemen, it's no bluff! From the study designs of a highway bridge we shall now go on to designing real bridges.

How did I ever get here? I looked about me in amazement. Kievo-Pechersky Monastery... But I wanted to go in another direction, to the Brest-Litovsk Highway; I

was anxious to see my students, to tell them the news and ask their advice, but my legs carried me to the Dnieper where I was drawn by my thoughts.

From the top of a steep slope, cut up by ravines, I looked down on the river. How often I had already been at this favourite place of mine! From here I had a wide, seemingly boundless view of the Dnieper, of the vast blue spaces on the left bank and the pitiful wreckage of the Chain-Bridge.

Snow-white passenger boats sailed by, beating up a foam with their wheel-paddles. Blowing their husky horns tugboats towed enormous rafts with toy-like veneer huts or pulled loaded barges into port. The river lived its own noisy, gay and bustling life. Trains roared across it. And only the highway Chain-Bridge lay on the sandy bottom of the Dnieper.

It wasn't the first time that I had pictured to myself the four large spans submerged and half buried in sand. I had heard they could be raised intact. But how? When would we have such machinery? We couldn't very well get them out of the river by primitive methods—that would have been an incredibly long, hard and dangerous job. And then, who could guarantee that the iron, deformed by the explosion and the fall, could be utilized after lying in water for several years. I no longer wanted to think about it. The idea of utilizing the I-beams appealed more and more to me. The designing of the Kiev highway bridge could now become an actual fact. It was by no means easy. I could foresee considerable difficulties in using the I-beams, but hoped we would overcome them. I was also tempted by the uncommonness and novelty of the task. The harder, the more interesting!

The crunch of a twig under somebody's foot diverted me from my thoughts. Nikolai Galuzinsky, one of my graduating students, came out of the shrubbery and stopped near me.

"Good morning, professor," he said embarrassed. "Just thought I'd stretch my legs a bit."

"There, there," I laughed. "I know very well what brought you here. You are bridge-sick, that's what you are. And don't you say no."

"I am bridge-sick." A broad smile crept over the student's face and his embarrassment vanished.

"And if you are, then listen to me, young man." I sat down on a big boulder and seated him next to me. "Remember I spoke at one of my lectures about prefabricated strategic bridges over the Dnieper?"

Galuzinsky hastened to nod his affirmation.

"But do you know where the iron beams are that were left after the bridges had been dismantled? You don't?"

No, he did not know.

"Well then, these beams are lying quietly on the banks of the Dnieper waiting for us to think up some way of using them for reconstructing the bridge. Get the idea?"

"Why, that's simply great!" the student shot out artlessly. "The mountain goes to Mohammed, professor. That means we'll have a bridge?!"

"Don't be so hasty, my good boy," I cooled him down. "There's plenty of hard work yet before we get that bridge."

"Why, that's just what we want."

We came back to town together. Galuzinsky was one of my best and most capable students, and when his first excitement wore off we very thoroughly discussed the idea of using the I-beams. I purposely advanced all manner of objections and doubts and then we jointly disproved them. As a result the idea appeared sound, business-like and deserving of support. This conversation was later continued at the institute with the participation of a large group of graduating students. They all approved of Shcherbina's idea and suggested we take the work of designing upon ourselves.

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Two or three days later I went to Shcherbina again.
"I've come with the answer," I said before I had crossed the threshold of his office.
"What is it?"
"I'm for it. I think we'll be able to cope with it."
"That's fine," said Shcherbina. "You and your students have done enough amateur work, so to speak. We offer you a contract with the Department for the design of a new girder highway bridge over the Dnieper. What do you say?"
"We're ready to start working even today."
"Congratulations then, Comrade Paton. We'll fight for this project together. The Government will give us the means, the people, the machinery, and will provide the plants for the manufacture of the spans. The rest will depend on ourselves."

And so the Department favoured a girder bridge. Still the struggle for the method of reconstructing the highway bridge continued and became increasingly sharper. Advocates of the old bridge predominated among the bridge-building engineers and architects of Kiev. We, who opposed the reconstruction of the bridge in its former shape, were in the minority. For two years prior to that we had studied the state of the bridge before its destruction and its history. Having convinced ourselves of its insecurity we came to the final conclusion that the only correct solution was to build a new span-structure with the I-beams we had on hand.

We stubbornly defended our point of view because we were against harmful extravagance, against dragging out the construction, against "it may work out" and unnecessary and absolutely unjustifiable risks. Our adversaries based themselves on so-called traditions, on their attachment to the olden times, and building so large a bridge

with the materials we had on hand, which meant treading new and unknown paths, frightened them. We were right, but the advocates of the old bridge would not yield. They rejected our proposal on the grounds that we would have to give up the chain-system bridge known for its beauty and abandon an historical monument which was dear to the hearts of all the people of Kiev.

We, too, were, of course, patriots of our city, we also cherished the beauties of its structures, but we did not intend to idealize the olden times just because they were olden times.

The former Chain-Bridge had had very considerable defects which we could not overlook, let alone reproduce them now in reconstructing the bridge.

We had made all the necessary calculations and ascertained that, if the Chain-Bridge were reconstructed in its former shape, we could never raise it to a height of 5.85 metres above the highest water-level in accordance with the technical requirements.

The patriots of the old bridge admired its chains, but ignored one of its prosaic, though very essential, "details" —the insecurity of the continuous-chain system. The history of the tragic destruction of the bridge in 1920 had not taught them anything. An explosion of one or two chain links proved sufficient to demolish at once the five spans of the Chain-Bridge. Only one small span had remained at the left bank. A multi-span chain-system bridge could be similarly wrecked by the destruction of one of its piers either through an explosion or through the erosion of its foundation.

The chains, so dear to the hearts of some engineers, had yet another vulnerable spot: walled into the masonry of the abutments they were the general defect of all chain-bridges. The chains of the Kiev highway bridge had been drawn through channels, which ran through the thickness of the abutments and were anchored in ribbed

cast-iron plates by means of iron pins. At these points the chains rusted considerably. The question of a capital overhauling of these points was raised as early as 1911. In 1914 it was decided to fix similar chains over the existing ones and anchor their ends in new masonry. For this it was intended to spend 180,000 rubles in gold. Work began soon afterwards, but the war interfered.

If the chain-system were retained for the new bridge it would have been impossible to use the old anchorage, whereas to do what had not been done in 1915 would cost one-seventh of the total cost of the bridge. The history of the bridge showed that its stone piers had occasioned a great deal of trouble; they were repeatedly repaired, but still remained weak and retained many defects.

It must be said that in its last years the Chain-Bridge was considered insecure and no longer met the traffic requirements of the time. This is testified to by the rigid restrictions and traffic rules established as early as 1913.

From all I've said the reader should get a clear idea why my pupils and I were opposed to a simple duplication of the old bridge. We were armed with all manner of calculations and findings, as well as the conclusions of many commissions.

Basing ourselves on facts and calculations we demonstrated the advantages of the design for reconstructing a girder-system bridge, using the I-beams we had on hand and dismantling the stone portals on the piers.

What were the principal advantages of our design?

First, the convenience for navigation. It was possible to raise the span-structure even to a height of 10 metres above the high water-level without any difficulties. Second, the piers were to be made lighter owing to the elimination of the stone portals. Then, the bridge would be built faster, since we would have to spend no time on

salvaging the submerged iron. The extension in construction time would have made it necessary to maintain, meanwhile, the weak wooden Navodnitsky Bridge, which would have cost 200,000 rubles. Furthermore, the trusses were more rigid than in the chain-system and an explosion in one of the spans of the bridge would not have caused the collapse of the trusses in the other spans, etc. And last but not least, the girder-system bridge would have cost approximately one-third less than the chain-system bridge.

As to the idea of reconstructing it as an historical monument, the following question unwittingly arose. It was intended to build a temporary bridge for 15 years. What was the sense then of reconstructing a "monument" for so short a time after which this monument would have to be destroyed? On the other hand, if the bridge held out longer, then, as was already said, the chain-system, which did not permit of raising the span-structure to a height of even 5.84 metres above the high water-level, would have been a hindrance to navigation for a long time. It was unthinkable that the Kiev Chain-Bridge, which was considered weak and unstable, before its destruction, should become a solid and rigid structure after its reconstruction. It was rather to be expected that it would retain the instability typical of the chain-system and the traffic over the bridge would again have to be strictly limited.

We had set to work immediately after signing the contract with the Department. If I had worked alone it would have taken me a long time to get the working designs ready, whereas it had to be done in a very short time. Besides, I considered work on such an assignment very useful to my Institute wards. They willingly responded to my offer, and I soon had a group of five young engi-

neers—my former pupils Tubyansky, Galuzinsky, Kovelman, Marakin and Dunayev, and ten graduating students. The Institute met us halfway and gave us a large draughting-room.

The final scheme of the new bridge did not come out right away. We had to draw up several draught designs with various systems of I-beam trusses, as, for example, cantilever-system trusses (Galuzinsky) and trusses with parallel bands with chain bracing (Tubyansky).

These designs, made under my supervision, were sent to the Scientific-Technical Committee of the People's Commissariat of Railways. We hoped, by receiving encouragement and practical advice, to finish our work soon and hand in the final working designs.

It all turned out differently. Our draught designs were rejected and the very idea of our design was vigorously opposed in the Commissariat's Department of Maintenance. Discussions on the necessity of salvaging the submerged iron and of reconstructing the Chain-Bridge in its former shape were resumed. The idea, we had contested in Kiev for more than two years, was now championed by a strong group of workers—professors and architects—at the People's Commissariat of Railways. One of the bridge-reconstruction organizations submitted its own design along these lines and wanted to take upon itself the entire construction.

There was the danger that the important affair would again be drowned in discussions and endless arguments. That was the way it looked. 1923 passed and 1924 began, but there was no end to stubborn and useless arguments. All this made us suffer very keenly. Some way out had to be found, decisive measures had to be taken.

One day, in February, 1924, I confided my sad thoughts to my wife and painted the whole picture to her. It looked like a vicious circle: we had got the upper hand over our adversaries in Kiev, worked hard and created some-

thing real and here we were no better off again than at the start.

"What do you intend to do then? Whom could you consult?" asked my wife.

"I have an idea. I want to go to the regional executive committee."

"Regional executive committee?" my wife was surprised. "What can they do?"

"Nothing ventured, nothing gained. Maybe they can do something. I think I better go right away."

"But what will you say to them?"

"I'll tell them everything as it is; besides, they know it all themselves. I'll ask them to intervene and put an end to this procrastination. What do you think?"

"Go ahead," was my wife's short answer.

I left the house with a firm decision of executing my plan. I thought it was the right thing to do.

Out in the street I fell prey to doubts again. They were born the moment this visit had occurred to me and now they came and went with increasing force. What will they think of my coming? Is it the right thing to do? Not only am I no Party member, I'm an old "specialist" to boot. Won't they think I'm trying to get in their good graces? That would be very unpleasant.

To be sure I had come across many Communists in the Highway Department and in various railway organizations; besides, there were some of them among my students. But, as a rule, I had only business relations with them. Now I was going on my own initiative to complain against the transport leadership. They may even consider it indecorous.

"But what has decorum got to do with it?" I asked myself angrily. "Or do they think that stringing us along for more than six months and trying to flop our project is at all decorous?"

I stopped short in front of a big grey building with

signs in Russian and Ukrainian, but at the same time the wide massive door opened and several young men came out into the street.

What a surprise! They were my pupils, members of the Party unit. After Lenin's death and in response to the Party's call for members the number of Communists at the institute doubled. I was sure they had noticed me, but made believe they hadn't recognized me. It was all too possible they had come here for the same reason I did. Sensing their inquisitive eyes on me I hurriedly grasped the copper door-knob.

In the regional executive committee I was received by one of its ranking workers.

"We've been awaiting your visit for some time," he said, greeting me.

I had prepared myself for anything but this phrase, and these simple and cordial words made me immediately feel as if he were a good old friend, who could not but share my anxieties.

"If you have expected me, then you surely know why I have come," I began. "Let's get right down to business. As you well know, we propose to build a highway bridge over the Dnieper with what we have on hand. We would have to wait too long for new metal which is needed for other purposes. As you see, we are practical people."

The official nodded in approval.

"Maybe, and I'm almost sure, our bridge won't be so beautiful as we should like to," I continued, "but by the next high flood we should be finished with the construction."

To myself I thought: "Wasn't I too sparing of words in putting my case to him?"

"Will you have enough of those I-beams?"

"Our students had visited the place together with the contractor and took careful inventory. We'll have more than enough."

"But if I am not mistaken," he leaned towards me, "the profile of I-beams does not make for good joints?"

I looked at my interlocutor with unconcealed surprise. He seemed to know something about bridge-building and was able to locate the weak spots at once.

"We've thought this over, too," I responded quickly. "True, it's the first time we're solving this sort of problem. We'll join the beams with hinges." And running ahead of objections, I made a point myself. "You'll say we need metal. But we are not asking for anything; the hinges can be made of old car-axles."

My interlocutor leaned back in his chair with an air of satisfaction; he looked as if a load had been taken off his chest.

"That's fine. But still, why do some of the comrades from the People's Commissariat attack you?"

I had a feeling this man was my ally, but one who would not trust his sympathy for an idea or the first impressions alone.

"Now you judge for yourself. Like those people in Kiev, who hold the same views, they propose to raise the distorted iron from the bottom of the river and to reconstruct the bridge in its former shape. Outwardly it's tempting, isn't it? But these critics of ours are up in the clouds. Cut up the submerged iron? But that means junking it. It is impossible to raise whole parts of the bridge intact. Hence the conclusion..."

"It looks good on paper, but when you come right down to it there's nothing in it, eh?"

"Exactly! It's strange, though, you are not a bridge-builder, but you see the point."

"Why, Comrade Paton, we Bolsheviks must see through everything and that's what we are learning to do. Incidentally how long has this been going on? Eight months? But this is a luxury we can't afford."

He was silent for a while.

"But do you know, professor, your critics are right about one thing though. Your trusses look rather dull, monotonous. Couldn't they be made a little more graceful, as architect Shchusev wants them to be. They should be pleasing to the eye. Our people deserve it."

I was aware the reproach, so mildly expressed, was justified. I felt quite awkward about confessing it, but false pride was not in my nature.

"I must confess this is our weak spot. But let them only say the word and we'll take care of it."

I rose to my feet.

"What is your last word?"

"I thank you from the bottom of my heart for your trust in us and your visit; I hope your design does not have a single blemish."

I lingered a while at the door.

"And is that all?"

"Give us a chance to think it over at the regional committee of the Party, will you?"

I had to laugh at this change of roles.

On my way home I was immersed in thought. Why was I so happy? Why was there music in my heart? Did anything really happen? Well, I was heard out; there was an interest in and an understanding of what I proposed to do; there was even sympathy, though I was not promised anything essentially. But I was undeceived by the outward reserve and chariness of words. The eyes of the Communist, to whom I had spoken, expressed much more than did his words. Then his remark on the exterior of the bridge: "The people deserve it!"

On the stairs leading to my apartment I wondered what my wife would say when I tell her my story.

"I talked to a fine person at the regional executive committee, Natasha," I said to her.

"Well?"

"One hour made me feel like an old friend."

My wife looked at me as if I had told her that in the midst of the raging February snow-storm trees broke out into blossom in the institute park.

"Maybe you've joined the Communist Party, too?"

"On the contrary, he joined the bridge-builders."

Looking at the amazed expression on my wife's face I laughed involuntarily and told her all about my visit. Many years later my wife confessed that, by some special sense, inherent only in very intimate people, she had divined at the time that something of very great importance to my whole life had happened and that it had been much more than the fate of the Chain-Bridge.

In May of the same year (1924) I was summoned to the regional executive committee. To forestall disappointment I prepared myself for the worse. Our opponents were striving to get things their own way and would not give in. Will they have the last say?

I felt very uneasy as I entered the familiar building.

I was immediately asked to read a certain document. I began to read and instantly beamed with joy. It was the decision of the regional executive committee and the regional committee of the Party categorically demanding that the bridge be reconstructed according to our design and that the work begin without any delay.

"And what about our opponents?" was all I could ask.

I was offered another paper. High Government bodies agreed with the regional executive committee and the regional committee of the Party and approved of their decision.

The bitter controversy, which had lasted so long, was finally decided in our favour and, what was most important, for the common good.

It was a complete success.

"Are you satisfied, Comrade Paton?" I was asked. "Now we'll span the Dnieper banks and connect the city with the countryside."

I wanted to open my heart:
"I never expected to find real friends here."
"We know that, but we found a friend just where we did expect to. The important question now is where we should order the span-structures to be manufactured."
I knew this question was coming.
"We have no choice. The Dniepropetrovsk bridge-building plant is the only place."
"Hm... Transport the beams there and then bring the manufactured members back? Besides, it's too far to keep an eye on."
"Can't help it."
"What if we have it done in Kiev?"
With that I could not agree at all.
"Did the Kiev plants ever build bridges, especially such bridges?"
My thrust was immediately parried:
"Did anyone ever try to build permanent bridges with such beams?"
I insisted:
"No use. Ask at the plants and they will tell you."
"They've already told us. Delegations from the Arsenal, the Bolshevik and the Lenin Forge visited us and the regional Party committee; they all declared they would not let this order go out of town. 'The Kiev bridge must be born in Kiev,' say the workers and engineers. For them it is not just another order. And now, what will the designer say?"
The designer sulked in silence. The idea appeared noble and patriotic, but more than risky technically.
I couldn't and wouldn't resort to archness.
"Excuse me, but do you believe in your Kiev plants?"
"We do, fully. And you?"
"I don't know," I mumbled.
It took the joy right out of me. I had just seen myself at the goal, and suddenly all these complications...

5. WORK OF THE PEOPLE

One evening in December, 1924, I was coming home from the Lenin Forge. I left the plant together with Galuzinsky, my former student, the one with whom I had but recently stood on the steep slope of the Dnieper examining the wreckage of the Chain-Bridge and making plans. He was now the chief designer of the plant.

We were walking in a crowd of workers who had just changed shifts. Two of them were talking loudly about the future bridge. Galuzinsky and I listened involuntarily to their conversation. The workers observed with alarm that, judging by the abundance of snow, the high water on the Dnieper promised to be early and stormy, and that we would have to hurry with the riveting of the trusses if we wanted to remove the scaffolding in time.

We were amazed: that was exactly what Galuzinsky and I had just talked about. I looked at the workers once more; maybe they were engineers I did not recognize because of the overalls they had on? No, they were not; Galuzinsky told me they were ordinary riveters from the boiler shop.

This, accidentally overheard, conversation made me recall all that had happened in recent months. In May I left the regional executive committee totally perplexed. I felt uneasy. Several days later I learned that, my objections notwithstanding, the order was given to Kiev plants. Could they cope with it, and how much time would they need if they could? The bridge would have to stand the most serious test and yet its fate was in the hands of people who had no experience in bridge-building.

In the beginning of June I was instructed to prepare the final working designs of the bridge. I was given very little time for it—only two months. The design was ready in August. The demand for greater attention to the exterior of the bridge made all my pupils and assistants—

young engineers and graduating students—apply all their faculties and powers. As a diploma design Galuzinsky had presented his version of a bridge with cantilever trusses built of I-beams. Kazyuchits, Kovelman and Marakin took part in addition to Galuzinsky in executing the final design. We all worked in harmony, everyone doing his best. The work of secondary importance was done by ten students of the institute. It was excellent pre-graduation practice.

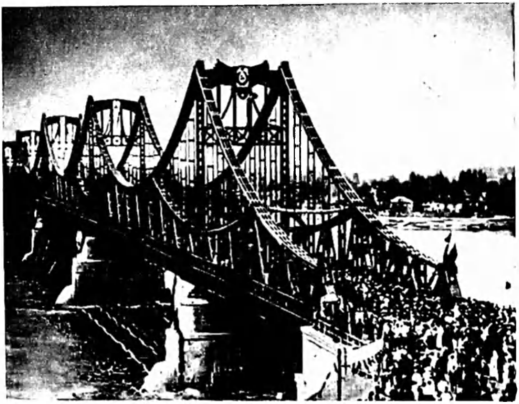
A bridge-building administration was set up in the meantime with engineer Berezin at the head and me as chief consultant. It was decided to manufacture the span-structures in Kiev, two spans in each plant. The Bolshevik plant was given the order for two short bank spans of 36 metres each, while the Arsenal and the Lenin Forge were to build two 143-metre spans each. No allowances were made for inexperience; the span-structure was to be delivered by February of the following year.

I was very much worried; the time was very short even for real bridge-building plants, yet it was dictated by the necessity of removing the scaffolding from the river before the spring ice-drift. Whether I liked it or not, the plants were given the orders and had to cope with them. I decided my place as consultant was in the plants rather than in the Administration.

I soon came to terms with the chief of the construction. He was an old acquaintance of mine, a competent and experienced engineer, who in 1896 had built the Perm-Kotlas railway. Berezin was, as it were, a hereditary bridge-builder. His father is known as the builder of the first large bridge over the Volga at Syzran.

It was not without embarrassment that I had entered for the first time the offices of the Kiev plants' directors. These plants had formerly been owned by foreigners and their directors had been venerable engineers.

Whom would I see there now?



Opening of the Kiev Bridge over the Dnieper (1925), built after E. Paton's design to replace the Chain-Bridge destroyed by Polish whiteguards

At first sight my apprehensions seemed justified; the director's chair was occupied by a former ordinary worker. What was I to say to him and how was I to say it? The director of the Lenin Forge, however, was able to facilitate my task; he simply took me to the shops. As soon as the workers heard the designer of the bridge had come, they surrounded us. To my surprise they already knew a great deal about the bridge. The time limit did not disconcert them and they even promised to outstrip the other enterprises. Nor did the novelty of their task perturb them for they trusted their wit and experience, and knew they could rely on the knowledge of their mechanics and engineers.

"Don't worry, professor, we won't go back on you," an old boiler-maker said to me with an air of dignity. "We're not working for capitalists. Am I right, fellows?"

The fellows he addressed were old workers like himself, half deaf with the constant roar of the riveting hammers.

"Our bridge will be a beauty," one of them answered for everybody.

Since then I was quite at home at the plants. I was well known in the shops and was often called to various shops for consultation. If I failed to show up for a week the workers inquired after my health.

"How about the scaffolds, are they ready?" the workers would ask me whenever and wherever they saw me. "What's doing on the bank? Enough cranes there?"

They took an interest in everything, they wanted to know all.

The trusses were being riveted with increasing speed. Each plant jealously watched the others. No sooner did I say that the neighbours "moved faster," than the man I spoke to would hurry to his work-bench.

Not only the workers whose conversation I had overheard in the crowd, but all the others were also worried

about the coming spring ice-drift. We had to forestall it at all costs or the scaffolding would be smashed into smithereens and a whole year would be lost. Moreover, the ice-drift could carry away part of the bridge. The workers and engineers were imbued with labour enthusiasm. Many machines were specially refitted or re-adapted in order to expedite the manufacture of the trusses.

All work in the plants was to be finished in February. Calls for world communism and other political slogans were a customary sight on billboards, but all one could see on posters in the plants now was the word—February.

I found it hard to confess to myself that I had not known our plain people until then, but I was satisfied my former ideas of them proved erroneous.

At the regional executive committee I was never reminded of my recent obstinacy; they knew I was spending half my time in the plants.

The opening of the new bridge was set for June 10, 1925.

The bridge was assembled in tense atmosphere. The threat of the coming ice-drift urged the workers on and they worked as hard as they could. The bridge was assembled conscientiously and in due time with no allowances for the "conditions." Everyone from the construction superintendent to the last riveter knew that the bridge would be subjected to strict tests, but they awaited these tests with unruffled calm. Soon the bridge was tested for all possible loads and passed all tests with honour. It is hard to say who rejoiced more—the designer, the bridge assemblers or the workers of the Kiev plants. It was a mutual check-up and a common victory.

The day of the solemn opening had finally come. I expected a great deal of it, but it was only when I arrived on the site with my wife and two sons that I understood the full significance of the forthcoming solemnities.

Quite a number of bridges had been built in Russia after my designs, but their opening had always been a matter of private concern of a few people—the designer, the contractor and the local railway or public authorities, with sometimes a banquet given by the client for the notable guests.

This time I saw something I had never seen before. Thousands of people were streaming from all parts of Kiev towards the bridge decorated with green garlands and red banners. Factory and office workers marched in close order with colours flying and bands blaring. Mothers carried their children in arms; here and there songs burst out. The most honourable place at the very bridge was reserved for those who in so short a time created this beautiful structure—my new friends and comrades in work—the people of the Lenin Forge, the Arsenal, the Bolshevik and the builders and fitters who had outraced time. I thought that quite natural. They were the heroes of the festivities; they knew many sceptics had prophesied failure and now they were rightfully celebrating their victory.

For the first time in my fifty years of life did I see such a spectacle.

The terrain adjoining the bridge was increasingly filling with Kiev crowds. These were joined by multitudes of peasants from the left bank of the Dnieper, from the direction of Slobodka, who came of their own accord from the nearby and distant villages to congratulate their factory comrades. I had often read in the newspapers of the union between town and country, but only now, and probably for the first time did these words sound real and concrete to me.

I scanned the delegates from the left bank, the decorated bridge, the steep Dnieper slopes where thousands of people awaited the beginning of the ceremonies, and asked myself:

"Could this have been possible at any other time?"

Among the festively dressed people of Kiev (many of them had come, like myself, with their families—wives, children and old men and women), among the happy faces around me, in this new atmosphere of general enthusiasm I had never experienced before, I had an entirely different feeling of the significance of my work.

Formerly, all I had done had been my own, personal, and in a manner of speaking, inner affair. Now I saw that my ideas, projects and thoughts had, in a way unnoticed by me, become part of what the whole people lived by. Here, over the Dnieper, it occurred with greater clarity to me that for the many thousands of people, filling the embankment and covering the steep slopes, this was not just a bridge. Not at all. They had built it with their own hands in plants, which were unadapted for this work, with their hard-earned money, without foreign "advisers" or money-lenders. This proved a great check-up on their creative forces, their abilities, their maturity.

Just five years before, on June 10, 1920, on the same Dnieper slopes the people greeted their liberators—the Red Army men, who were fighting their way across the river on rickety pontoons. At that time the bands blared in honour of the battle heroes, now they glorified the heroes of labour, for over the water there hung a fine bridge more than three-quarters of a kilometre long—an obvious and material embodiment of what emancipated labour could do.

And not only this giant, but even the small tram-cars which had rusted for five years in the depot, now rolled with a merry cling-clang from the Podol to the bridge and filled the hearts of the Kiev inhabitants with joy. In those days even the reconstruction of the tramway line was considered a great success.

More than a quarter of century has elapsed since that day and I can hardly recall all that was said by speakers at the meeting, but though I have forgotten the exact words I shall long remember the ideas and sentiments expressed. The speakers included representatives of the Government, of municipal organizations, of trade unions, the railway administration, Red Army commanders, workers of the Kiev plants, peasants from the left bank of the Dnieper. They were men of different occupations, of different ages, of different life experience, but their thoughts were common to all.

"Today's holiday shows," they said, "we can win not only in battle, but in labour as well."

"Such successes as the reconstruction of our bridge are only the beginning; the working class has proved it can build without the bourgeoisie."

"Ahead of us we have titanic work which will change the face of the country, all its life. Let the bourgeois world rage and rave. Each victory, like this one, strengthens our faith that with the Communist Party at the head we will conquer any and all difficulties."

I rejoiced particularly at the words that the men of science had worked on the reconstruction of the bridge honestly. Ordinary workers said that the "union of labour and science" would make the country even stronger, that the "intelligentsia was increasingly merging into the firm union of the workers and peasants." I realized for the first time my work was considered important not only by specialists, but by plain people as well. Until then I thought that, as an engineer, I was only helping to reconstruct the bridge, but now it turned out that others saw into it much deeper than I did myself.

I was totally nonplussed when asked to speak. I was greeted with an ovation which only increased my embarrassment. I had always felt rather ill at ease when I had to address a banquet or speak at some official anniversary.

I spoke of the importance of the bridge; I said we owed our success to the close unity of all who took part in its construction; I voiced my firm belief that those who were able to cope with the bridge would, in the future, prove equal to greater deeds.

Then I took heart and my words began to flow easily and generously; I felt as though I were in the chair of some unprecedented university, in a lecture-hall without walls or ceiling, in a university where I was not so much a professor and teacher, as a student. Both my audience and I had one and the same teacher—the new life which I had already accepted for its irresistible movement, its scope and purposefulness, though I had not as yet made it fully intelligible to myself.

After the meeting the red ribbon was cut to the sounds of the *Internationale* and a human avalanche rushed with a thunderous hurrah onto the bridge. One after another the tram-cars followed. I was asked to take my place beside the motorman on one of them. This simple mark of attention moved me very deeply. Hirelings, whose work is appraised only in terms of money, are not treated this way. Forgetting my usual reticence I waved, as did the others, to the people who walked or ran close to the tram-cars or rushed to greet us from the opposite bank of the Dnieper.

That day, when the new highway bridge was solemnly opened in Kiev, gave me a great deal to think about. Work had always been the most important part of my life; I could never picture to myself life without work. But that had been work of a lone person and it had never given me full satisfaction. Now I knew in my mind and felt in my heart that my personal work merged with that of millions of people.

Life itself took me by the hand and led me out on a wide road.

6. SECOND YOUTH

The country was going through a period of reconstruction. The very air seemed saturated with young and ebullient energy. We, the people of the older generation, the old specialists, who worked honestly with the people, learned to rejoice in the events that had formerly touched us but very little and had not been part of our personal lives. A few new blast-furnaces blown in—it's a holiday. Another open-hearth furnace brought back to life—you feel richer yourself. Increasing quantities of coal are delivered to every part of the country from the Donets Basin coal mines, but recently flooded and wrecked, and you rejoice as if the blood began to course faster through your own veins.

Cloudlets of smoke were rising from the smoke-stacks of dozens of restored plants and factories.

All this was happening much faster and on a greater scale than I could have ever expected. What I thought needed decades came to pass in 3-4 years. The numerous conjectures and prophecies of the old bourgeois world that the Soviet rule would soon and inevitably degenerate and fall now seemed ridiculous and miserable to me. In their camp they branded people like me as "traitors." Well, the fury and hatred of the enemy confirms better than anything else that you are on the right track.

I was now nearly 60 years old, but I had never before felt so young and vigorous. I had scrambled out of my "professorial" shell and no longer tried to hide myself from life. On the contrary, I was afraid lest I lag behind it. Truth to tell there were times when I did not recognize myself. At the time we were reconstructing the Chain-Bridge people came to help us from Syzran and the Irtysh. Now I wanted to "reach" the most remote parts of the Soviet land, if not personally, at least through my designs, my books and the labours of my pupils.

This feeling determined the nature of my work with the graduating students at the Kiev Polytechnical Institute. At that time we all had common interests, the principal interest being our desire to help our country in healing its wounds as fast as possible. Life itself suggested and dictated the themes for our diploma designs. The students were very anxious to work for the burning and urgent needs of the motherland. Besides, life, like never before, offered every opportunity to daring and inquisitive minds. I saw the enthusiasm of my students and guided them in finding the best practical methods of new bridge-designing and of reconstructing old blown-up bridges. I persuaded them that an idea which is just attractive and clever in itself, but is devoid of any practical value, is only good for mental gymnastics, but not for actual help, which our builders were expecting from us.

It was all important and necessary work, but reconstruction of wrecked bridges was a particularly vital problem.

In several years we had accumulated in our diploma designs very interesting and rich material. I remember two of them—detailed designs of powerful hoists—were especially clever. Their practical value was incontestable. With the aid of these truss-hoists the blown-up span-structures of bridges were lifted to their former height. There were still many such bridges at that time.

It would have been a crime to keep this material back without working it up and publishing it. We set to work and finished it in a relatively short time despite the difficulties and complexity of the task. The transport was given a three-volume manual on reconstructing blown-up bridges. For this I am largely indebted to my fellow-engineers Moskovenko, Tubyansky, Tatsitov, Damsky, Leontovich. Most of them were my recent pupils. Many students of the Kiev Polytechnical Institute took an active part in composing the drawings for the atlas; they worked

very hard and received but a modest remuneration. For all of them bridge-building was not a profession picked at random, but a real life's calling. Many of them are now heading departments in schools of higher learning and are passing on their experience to the rising generation.

I might say in passing I always loved to work with young people who were free of the inertness and routinism so typical of the so-called recognized specialists of the time. For decades my invariable assistants in the work on designs and my co-authors of textbooks were students and young engineers. The difference in our ages grew with each passing year: I was getting older while in the lecture-halls and in the draughting-rooms youth continued to blossom and bubble over with vitality. What always attracted me to the young people was their love for work, their constant search for new untrodden paths, their readiness to dare and risk boldly.

But let us get back to the three-volume manual of which I began to speak.

This time, too, in working on the manual I conformed to my old and tested rule never to rely only on myself, my experience and my knowledge. The manual generalized the experience of my many former and present graduating students; it included everything that was of any value in the archives of the Administration of the South-Western Railways, building organizations, railway battalions, etc. I frequently discovered that my ideas were reflected and developed in what they had done, that these ideas had already been realized and had stood the test of life. Life taught me that only on the basis of such co-operation was the development of any branch of engineering possible.

My other works of that period were also based on the same principle; these included the *Prefabricated Iron Bridges*, a new and enlarged edition of tables for calculat-

ing bridges, a manual of draft bridge designs with an atlas of drawings of stone abutments and piers, etc. I believed it wrong to republish my books with no regard for the fact that life and science had meanwhile marched ahead. That is why before publishing together with Gorbunov, my talented and favourite pupil, a new edition of the *Course of Iron Bridges*, we enlarged it and thoroughly revised all that was outdated and obsolete, and enriched it with all that was new and advanced.

In designing bridges before the Revolution attention was principally paid to the stability of the bridge structures with no regard for the amount of work they required or the conditions under which these structures had to be manufactured in the plants. The convenience of riveting the joints, the simplification of their assembly in the plants or their subsequent installation never interested the designers. But an unfortunate disposition of the assembly joints, or inconvenient riveting connections in the joints hampered the work and raised the costs. What that meant in practice can be shown on the following typical case. A large bridge over the Yenisei on the Siberian railway was being built during severe frosts. To insert certain rivets in the bearing joints of the trusses a worker had to crawl through a narrow opening into the completely closed joint-box. It was so close inside that the worker had to take off all his warm clothes. To keep the worker from freezing he had to be given vodka as long as he was inside riveting.

These barbarian methods of work and disregard of man verging on crime had to be done away with. In the new edition of our *Course of Iron Bridges* we were setting forth and defending a perfectly new method of rational designing based on dividing the bridge structures into enlarged assembly members completely manufactured in the plants. As a result the construction of bridges would now be much cheaper and require much less time. The

advantages of this new method were immediately apparent and it soon won general recognition and was put in practice. It was fervently hailed by the workers, which was but natural since it greatly simplified and facilitated their work. We were very happy at the thought that our textbook had played an important part in the victory of the advanced method. It took root not only in practice, but also in the student diploma papers in our and in other institutes.

I've always striven to persuade my students that the design of a bridge was not an abstract, speculative problem. I wanted them to see the bridge in work, in action, under various loads, and to have a clear idea of the different systems of trusses and the various types of beams. For this purpose I built for my department of bridges at the Kiev Polytechnical Institute a large model of a bridge for experimental studies of various problems. Two steel trusses of this model had a 15-metre span and the model was calculated for a 100-ton load applied in the middle of the span. The model was so constructed as to enable the students to measure the stresses and deformations with the load in any position, to create various systems of trussing and to make the most diverse joints between the cross-beams and the trusses.

I won't exaggerate if I say that the idea of building the model, so unusual for institute practice, was a fortunate idea. The students acquired firmer and deeper knowledge and working on their diploma bridge designs they were able to check their ideas and calculations with this model and, as we would say in jest, frequently "consulted" it. The numerous measurements made by students on this model helped us clear up many themes and technical problems important to science and practice.

The young Soviet Republic gained strength ever more noticeably and marched ahead with increasingly confident strides. This was evident at least from the building of

bridges. On the Dnieper alone, in the vicinity of Kiev, there was enough work for my department, for all our graduating students. The question of building new bridges, both railway and highway, over the Dnieper arose in 1925-1927. My students and I were solving complicated problems and we worked late into the night in our draughting-room. In two-three years we designed several versions of a city bridge from Pochtovaya Square, near the wharves, to Trukhanov Island, etc.

But we were not content with working only for "our" Dnieper and endeavoured to take an active part in building bridges in other parts of the country. When a contest for designing a large bridge over the Oka was announced in Nizhny Novgorod (now Gorky) we responded immediately. For the participation in that contest I organized a team, composed of two young and energetic bridge-builders and an architect, who designed two versions of a bridge under my supervision.

At that time I devoted a great deal of my attention and energy to supervising the scientific-research department of engineering structures. The department conducted research in some of the most important problems of bridge-building. I rejoiced at being able to draw many of my graduating students into this work. I should like to make special mention of three of them—N. Kornaukhov, A. Umansky and F. Belyankin. Graduated from the institute with honours, all three of them have become leading scientists in the field of structural mechanics and construction statics, sincerely devoted to their favourite work. The Soviet scientific and engineering world knows and reveres the names of Kornaukhov and Belyankin, members of the Ukrainian S.S.R. Academy of Sciences, and Umansky, Doctor of Technical Sciences.

In 1928 I was 58 years old, which was a respectable age; the last eight years had been the most intense, active and happy years in my life. I was an old engineer and be-

fore the First World War, in the prime of life, I thought there was nothing else to live for and I could retire and live the rest of my days in peace; now I felt young again and at the end of my three-score did not intend to be outdone by my pupils in any respect. The secret of this "second youth" was that I was no longer a "lone wolf," that I now felt hundreds of threads running from me to the people and from the people to me, and that at last I found my real place in life. Yes, that was precisely it!

And when I read in the newspapers in the same year —1928, that a saboteur organization of old bourgeois "experts" was disclosed in Shakhty (Donets Basin), I was not only indignant but also deeply shocked. It was beyond my comprehension that an engineer, who was called upon to build and create, should destroy, undermine and spoil, instead; that an engineer should dare raise his hand against that which was created by the labour of the whole people.

Obviously, I differed from these renegades in many ways not only in the present, but also in the past. They raised their hands against that which we—honest people —had created, and they became my enemies. In my eyes these vandals did not deserve being called human.

The days when these people were unmasked and tried were very important days in my life. I felt I was drawn even closer to the new people's rule. Its enemies had become my enemies; its friends, defenders and leaders were increasingly becoming my friends, my defenders and my leaders.

Part Three

NEW PROFESSION

1. SHARP TURN

In 1928 I was 58 years old.

I should never mention this in no other way remarkable date if it were not connected with great changes in all of my subsequent life.

More than 30 years, i.e., all the years of my self-dependent life after I had received my education, I devoted to my favourite work—the designing and building of bridges, the scientific work in the same field, the writing of textbooks and the training of young bridge-building specialists.

Thirty years is a long time in the history of modern engineering. Considerable changes had occurred during this period in every branch of science and industry.

Bridge-building was also characterized by a progressive process. It took place before my eyes and I participated in it myself. The methods of calculating bridges changed, becoming more and more scientific and, at the same time, simpler and more convenient; advanced engineers created new original designs of span-structures, which were lighter, stronger and more reliable; the methods of assembly were simplified and improved.

Only one thing remained unaltered—the method of joining the bridge members by means of rivets. Since men

had learned to build iron bridges they knew but this one primitive method.

New engineering methods were advancing everywhere and machines increasingly replaced the muscular efforts of man. Only in bridge-building slow, primitive and frequently exhausting manual work prevailed.

From a train window the passenger sees hundreds of small steel "buttons"—rivets on every bridge-beam. But only a rare passenger can divine the amount of effort spent on joining one beam with another.

And yet this is no simple matter at all. The insertion of just a few rivets requires the following operations: the two members to be joined must be marked and placed on one another, holes must be perforated and drilled, the rivets prepared beforehand must be heated, inserted in the holes and, finally, swedged.

This painstaking procedure is repeated thousands, tens of thousands of times during the construction of a single bridge. Imagine the work required to build hundreds of bridges! The labour that could be spared, the workers freed and the time saved, if we could only do away with riveting! But how? What could we substitute for the ancestral riveting? What could we replace it with?

For a long time I could find no answer to this question.

In the summer of 1928 I came to a small railway station to test a thoroughly reconditioned bridge. As soon as I alighted from the train I observed dazzling flashes at the end of the bridge. It appeared as though some gigantic mirror was reflecting the powerful rays of the sun.

"Electric welding?" I asked the mechanic who was with me.

"That's right. Would you like to see it?" the mechanic offered.

Electric welding... I had heard and read about it but had never seen it before.

We went to the bridge. Cupping my hand over my eyes

I stopped at some distance from the welder and began to observe him.

Straddling one of the longitudinal beams a young worker was welding a steel band to it. The welder's face was protected by a shield, which he held in his left hand while guiding the holder with the metal electrode with his right hand. The welder worked with gusto and rapt attention never taking his eyes off the end of a steel rod which melted quite fast and turned into a smooth and accurate seam. My eyes began to smart and I turned them away, but a moment later feasted them again on the welder's fast and dexterous movements.

After a while I left the welder and fell to thinking. The mechanic had to repeat the same question several times before I became aware of his voice.

I do not know how long I stood there immersed in thought, but my mind was hard at work. Maybe that was just the answer to the question which had so long tormented me. Maybe electric welding was just the miraculous force to replace riveting and drive it out of bridge-building. What a wonderfully simple and economical method of joining metal! Who knows but it may bring about a real revolution in the building of bridges, steel structures, carriages, ships and cisterns...

This exciting thought never left me as long as I stayed at the small railway station.

It often happens that as long as a person is ignorant in something, as long as he observes the thing from a distance, the thing appears quite plain and simple. It was the same way with me.

The outward simplicity of welding, the ease with which the young worker on the bridge had operated the holder, made me think there was nothing complicated about welding, that all one had to do was to put together the parts to be joined, switch on the electric arc, which will melt

the metal being welded and the eletcrode-rod, and the welding is done...

Upon my return to Kiev I felt I took seriously "sick" with electric welding. I continued to work on bridges but for the first time in my life my interests were divided. Without confessing it to anyone I began to make acquaintance of welders, to visit the plants, where I could observe actual welding, and to study all the available literature. It was then it dawned on me that electric welding was a real and independent branch of science in which a great deal had been done but still more remained to be studied. This did not scare me away; on the contrary, it fascinated me even more.

Just then I was preparing my *Course in Iron Bridges* for a new edition and for the first time devoted a chapter to electric welding in bridge-building. There were only five pages on this subject, but welding made its first appearance in a textbook of bridges as a rival of riveting.

In 1929 I was elected member of the Ukrainian Academy of Sciences.

At that time a higher educational establishment for transport was being organized in Dniepropetrovsk and it was decided to merge it with the Kiev Railway Institute, which had been separated from the Polytechnical Institute some time before. My department of bridges was naturally also transferred there.

Again I had to choose what to do. I hesitated and that was but natural.

On the one hand I had long been connected with bridge-building to which I had devoted the best part of my life. I felt sorry to leave the department and office of bridges, which I had created and for which books, drawings, models and devices had been collected over a quarter of a century. I could hardly picture myself outside the invariable and usual circle of interests.

On the other hand I was increasingly attracted by the

possibility of working in the Academy of Sciences in the new and promising field of electric welding. I felt a growing attraction for this work and with each passing day it appeared clearer to me that welding offered a scientist no end of work.

It is quite possible that if I had faced this dilemma several years earlier I would have remained true to my bridges.

To get an explicit idea of how and why I made up my mind the reader should recall what the year 1929 meant to the country.

I still remember very well one of the April days in 1929, when the professors and instructors were gathered in the geodesical hall of the Kiev Polytechnical Institute to be told of the first five-year plan adopted at the Sixteenth Party Conference. I listened very attentively to the report made by the Institute's Party organizer and was astounded by the grand figures he cited. An investment of 64,500 million rubles in the national economy in the course of only five years!

Only five or six years had passed since I designed the new city bridge in Kiev to replace the Chain-Bridge and could hardly get the necessary metal. Only five or six years!

And now the plan envisaged the construction of enormous metallurgical, tractor, automobile, locomotive and electric power plants.

Involuntarily I thought: "Is it at all possible? Where shall we get the tremendous means, the people, the specialists, who could cope with this unprecedented range of construction?"

Could I but sympathize with the extensive and daring plans of the Party? I joined them with my heart and soul.

But was this plan based on sober business-like calculations, or did it include day-dreams without any concrete basis?

This "but" rather embarrassed me and, truth to tell, many such "buts" occurred to me.

When I came home I opened the newspaper with the text of the five-year plan and laid a map of the Soviet Union beside it. The more I read the text of the plan and mentally distributed the future giant enterprises and electric plants on the map, the more fascinating this picture appeared to me. And again doubts and more "buts"...

Take the Dnieproges, for example. As far as I could remember this major construction was talked about in old Russia time and again. Talked about, yes, but all the designs and projects of hydro-electric power plants on the Dnieper rapids were buried in the archives of the tsarist government. Many foreign concerns had offered their services; many foreign electrical firms asked for a concession for this construction job. The Petersburg authorities rejected the enslaving terms of the foreigners but did not do anything to tackle this grand job themselves.

And now it was planned to build this grand plant in five years without any outside help. Was it possible?

I doubted it.

I doubted it and still wanted to believe, wanted life itself to dispel my innumerable "buts," to refute my scepticism.

Time wore on, if one could say so about its precipitate run then. I closely observed everything that was happening around me.

Work on the Dnieproges construction sites was already in full swing near Khortitsa. Concrete was laid even in severe frosts; the workers rammed it with their feet and wrapped the timbering in their padded coats to prevent the concrete from freezing. If the rushing streams of water happened to break through the obstructions the bravest of the workers threw themselves into the fight with the blind elements and closed the dangerous gap at the peril

of their lives. This heroism was looked upon by the whole country as something quite natural and self-understood.

In the newspapers I read the telegrams from Siberia, the Urals, the Donets Basin: blast-furnaces of unprecedented production capacity were built, buildings of plants were erected with the assembly of powerful rolling mills soon to follow... In Stalingrad a gigantic tractor plant seemed to grow up out of thin air and, despite the prophecies of American authorities, it required only about one year to build.

It all seemed like a miracle to me.

One could criticize the mistakes and blunders (they were natural in so enormous an undertaking), one could be anxious whether the new millions of workers would be able to cope with such first-class machinery, but not a single honest and unbiased person could shut his eyes on the facts, and the facts spoke for themselves.

The entire country was a construction site, and the flames of electric welding flashed on its scaffolding here and there. The newspapers and magazines printed frequent reports of how the steel electrode in the hands of the welder helped win days and weeks in the battle for time.

Welding was attacking the riveting. I saw that the future belonged to electric welding, that this, at first sight, narrow branch of engineering was fraught with great and truly inexhaustible possibilities.

And as soon as I definitely accepted it, my wavering ceased. I firmly decided to devote the rest of my life to welding and to set up a scientific centre of electric welding in the Ukrainian Academy of Sciences. I was 59, but it is never too late to begin anything, especially if your heart and soul are in it. I returned to the Polytechnical Institute in 1935, in order, like 30 years previously, to organize a new department, this time a department of electric welding.

2. I BECOME A WELDER

And so I became a welder.

I had to start my work in the Ukrainian Academy of Sciences actually from scratch. There was no equipment, no laboratory, nor even a more or less suitable room.

For the time being I decided to rely on the plant workers, on those who had already got a taste of welding. At the Bolshevik plant, where there was a welding shop, they willingly met me halfway and gave me a small room, which thenceforth bore the high-flown name of "Paton's Laboratory."

There, with a young electrical engineer and a-one-and-only welder, my practical conversion into the "welding faith" began. The welder was an enthusiastic man; he loved his work, knew it inside-out and manipulated the electrode like an artist. There was a great deal I could learn from him.

We began with the simplest, though, at that stage, perhaps, the most important thing. Among the leading personnel of the Kiev plants there were as yet very few people who were solid on electric welding; these people could have been counted on the fingers of one hand. To win recognition for welding we had first to prove that the welded structures were in no way inferior to the riveted ones.

For this purpose we welded beams with different cross-sections and with various joints in our laboratory at the Bolshevik and then tested them in the mechanical laboratory of the Polytechnical Institute. My old connections at the institute came in handy and soon the long corridor on the ground floor of the institute was filled with beams.

My decision to work in the field of electric welding and fully to devote myself to it puzzled some of my colleagues at the Ukrainian Academy of Sciences; some of

them were even inclined to irony. I was known as a bridge-builder, my election to the Academy served as a recognition of my work precisely in this field, and suddenly there I was--welding.

Some made allusions, others spoke plainly:

"Make so sharp a break at your age? What for? What is this welding anyway? It's all right for an engineer, but for a scientist... Oh, no!"

Someone even sarcastically called electric welding the "science of making a barrel without rivets."

This mockery, however, did not disconcert me; I knew these people simply had a very vague idea of welding.

I was aiming to set up an electric-welding laboratory in the Academy and therefore said in the Presidium:

"The Bolshevik plant was the first to give us a helping hand and we were grateful to it. It is high time for the Academy to take the welding into its bosom."

I was backed up. However, the Academy had no vacant light premises at the time and I was offered three rooms in the basement of an old building formerly occupied by the First Boys Gymnasium. I remember how the superintendent of the building brought me to a dark and damp basement cluttered with wood and all kinds of rubbish.

The sad picture of the basement depressed me. Apparently, catching on to my mood and wishing to dispel it the superintendent spoke of the prospects for altering the premises.

"These narrow apertures, Comrade Paton, we shall widen and make into real windows; we'll make a wooden floor and whitewash the walls. Why, you won't know the place. It'll be a picture of a room..."

"You are a master of suasion," I smiled.

"Honest, we'll do a wonderful job," the superintendent assured me.

To comfort me he was ready, it seemed, to promise me plate-glass windows, carpets and real palms.

I had no choice. I agreed to occupy the premises and began to make the necessary alterations. It must be said the superintendent was a man of initiative and really did all he could.

I took one of the rooms for myself and gave one to my fellow-workers. In the third room we set up a simple machine with jacks to test the beams for bend. It was impossible to bring the whole machine into the basement, so we had to resort to a complicated manoeuvre—dismantle it, throw the parts through the windows into the room and then weld and assemble them. The four-metre beams to be tested were welded in the yard and then brought into the room in a similar manner.

The laboratory staff consisted of four people including myself and the book-keeper, who also acted as superintendent, office manager, dispatcher, etc. But I did not lose heart. I knew the working conditions would change in due time; what was important was that an electric-welding laboratory had been set up in the Academy and that work in it had begun.

Whenever I hired young engineers I emphasized that it was the business of the electric-welding laboratory to help industry master new methods of welding metal rather than simply write wordy scientific reports. I warned them they would have to spend a great deal of time in plants to help them cope with the difficulties they might meet with in mastering the work of welding; I told them they would have to train welders for the plants and fight the adherents of riveting.

"If the conditions suit you, the job is yours," I would say to my future co-workers.

I had a similar talk with a man I had known for many years; I knew all his weaknesses as well as his strong points. The man was Gorbunov, formerly one of my talented students at the Polytechnical Institute.

Even at the student's desk Gorbunov stood out among

his class-mates with his brilliant talent and enormous industry. Even then he published articles on theoretical subjects in the field of statics of structures, which had attracted immediate attention. He was graduated from the institute with honours in 1923. I predicted a great future for him and was not mistaken.

What brought us together was primarily our common love of work. Gorbunov was not very robust and frequently fell ill, though this never damped his untiring energy. I was thirty years older, but this big difference in our ages did not stand in the way of our friendship. When we worked together on the new edition of the first volume of the *Course in Iron Bridges* I was able once more to appreciate Gorbunov's profound knowledge and his ability to think independently. Later Gorbunov started working together with me at the Kiev bridge-testing station where he was my main support.

I could certainly never have dreamt of a better co-worker in the welding laboratory.

Gorbunov had a true and acute sense of the new. Welding appealed to him as much as it did to me, and he was not afraid of the difficulties the unknown field of endeavour offered. I began with the problems of using welding in the manufacture of steel structures and that was precisely what he was working on.

We were only five in the beginning, but the tasks we had set for ourselves would have required five times as many people.

"What are we to do?" I asked myself. "We can't make the day longer; nor can we get the people we need and, besides, we have no place to put them, anyway. If we work in isolation with our own very modest forces we won't do very much."

Gorbunov was tormented by the same thoughts. One evening we stayed in my office after work. Gorbunov was pacing the room nervously.

"Well, Comrade Paton," he began. "You say we should not transform our laboratory into a monastery cell, that we should not become hermits. You're right a thousand times. But what should we do? How many of the Kiev plants can we visit, say, once a month?"

"But we must just the same," I objected. "We must maintain direct contact with life. Lectures in the plants, newspaper articles and radio broadcasts are all very good in themselves; we have been and will be doing all that. The trouble lies in our disunity. There are welders in the plants, on the railway, in the autogenous trust and elsewhere. But everyone seems to be for himself."

"Yes, but we only meet from time to time," he drawled. "Everyone is staying on his own side of the fence and thinking up his own subjects for research. That isn't right..." Gorbunov's eyes suddenly sparkled. "What if we call a conference, a 'unity congress,' so to speak?"

"It wouldn't be bad," I agreed, "but I've been thinking of something bigger. I should like to see with us, or around us, if you will, a public organization which would become the life of welding in Kiev or maybe in the Ukraine. I don't know what to call it... the Council... the Group... the Welding Committee?"...

Gorbunov seized a sheet of paper, wrote at the top in a bold hand: "Electric-Welding Committee of the Ukrainian Academy of Sciences" and offered it to me.

"This is just about what we want," I said.

Several days later we took our idea to the Academy. At first the idea somewhat puzzled our comrades.

"We don't quite understand what this committee of yours is."

"It is a scientific institution of the Academy with the electric-welding laboratory as its kernel. But it works on public, representative principles with the active participation of engineers and workers engaged in welding.

We will all profit equally by it. We shall not need any money from the Academy; the founding members of the committee will support it with their dues."

The project was unusual, but the leadership of the Academy gave us its blessings and the committee was set up the same year—1930. It was the first time within the walls of the Academy that workers from shops and depots sat, worked and argued about scientific and technical problems side by side with scientists and engineers. After a report made by an engineer—a committee member—the best Kiev welders went to other plants and made "co-reports" at the working places of the local welders showing them what an electrode could do in skilful hands. It never failed to arouse an important and animated discussion between the hosts and the guests right there and then.

Our laboratory and the Electric-Welding Committee soon merged. I considered stubborn and insistent propaganda of electric welding, propaganda by word and deed, to be their chief and most important work.

My association with industrial workers convinced me that most of them had not yet believed in the advantages of welding. The adherents of riveting were not going to surrender without a battle; a bitter struggle between them and the pioneers of welding was only just beginning.

In the journal *Autogenous Work*, under the heading "Welding or Riveting," I often found accounts of disputes and technical discussions in plants and in scientific and technical societies. In several of them, which were held in Kiev, I took part and sometimes made reports.

Administration representatives of some plants hailed the new method of joining metal, but invariably added:

"It all sounds very good, but let us have proof your welding is as reliable as riveting and more economical."

"We have all the proof you want," we would answer and would cite the results of our first researches.

"No, no," the sceptics would not give in, "you keep talking about your beams. Show us the same results on machines, on large objects."

The enemies of welding centred fire on its drawbacks of the time, exaggerating and abusing them in every possible way, and, above all, questioned the dynamic strength of the welded structures. We encountered this everywhere and it gave us food for thought.

Gorbunov and I called a "production conference" of two to see what we could do.

"Disputes and discussions won't get us very far," I said. "We must supply the people of industry with precise information to convince them that welding is reliable and effective and should be regarded with confidence. Do you agree?"

"Certainly," Gorbunov answered. "As long as our experiments on beams do not satisfy them we must test riveted and welded structures, which alone will impress them. But we can't do anything without equipment."

"We agree, then, we need testing machines," I said. "Do you know where we can order them?"

Gorbunov did not know. We decided that I should make inquiries through the Academy of Sciences.

I inquired immediately and found out that these machines could be obtained in a short time only abroad and at a very high price. Upon receipt of this information I sent for Gorbunov.

"It seems the machines have to be ordered abroad and at an enormous cost."

"How much?" Gorbunov asked.

"150,000 rubles in gold."

Gorbunov gasped with amazement.

"You don't mean it, Comrade Paton. We won't be al-

lowed this luxury. Besides, we ourselves won't have the heart to ask for it."

"What do you suppose we should do then?"

Gorbunov paced the room for some time, then stopped short before me.

"Well, then, Comrade Paton, let me design these machines myself. They may not turn out very beautiful to look at, but we'll be able to work on them, I hope. Shall we try?"

I felt the same way, but the speed with which I gave my consent appeared suspicious to him. He looked slyly at me.

"Didn't you have this idea when you sent for me, Comrade Paton?"

I could not contain myself and laughed.

"We have known one another for many years and there is no hiding from you..."

Gorbunov made all the designs and drawings of our first testing machines, we manufactured them ourselves and they cost only 20,000 rubles. Gorbunov jubilated. I was very thankful to him.

Now we were equipped rather well for the time. Before we conducted our tests by necessity only on laboratory "midget" samples. But to continue in the same manner would have meant to break a butterfly on the wheel. And what was more important, these experiments would not have carried enough weight for men in the factories, nor could they have yielded serious material for scientific deductions. Gorbunov and I dreamt of testing whole units of different machines and articles manufactured with the aid of welding. But we had no such machines at our disposal as yet.

A letter from the Kharkov Serp i Molot plant was the first swallow which heralded the recognition of our work.

"You are advocating welding everywhere and are

trying to persuade us of its advantages," wrote the director of the plant. "We've tried welding, but cannot as yet decide to use it on an industrial scale. Can you furnish real proof that welding is superior in the manufacture of threshers?"

"We can," I answered the director. "Please, manufacture and send us the carcasses of two threshers, one riveted and one welded, and we shall do the rest."

The scope of the experiment did not disconcert the management of the plant, and we soon received two carcasses. Both of them were subjected to most careful tests on a special stand, built in the yard of the Academy of Sciences. The tests showed beyond a shadow of doubt that the welded carcass was, to say the least, in no way inferior to the riveted one and that we could confidently recommend welding to the plant. And that was what we did.

The Serp i Molot plant began to manufacture threshers with welded carcasses. That was a big day in our committee.

We scored our second victory in Zaporozhye. The Kharkov story repeated itself: the Kommunar plant believed in, and, at the same time, feared welding. On our testing stand the carcasses of threshers were followed by frames of Zaporozhye combines. And the prestige of welding was firmly established in one more branch of industry.

But our relations with the various enterprises and departments were not always so good. At times there were sharp collisions and direct conflicts. Frequently we had to "throw our coats off" and fight conservative or lazy and inert people.

We fought with particular zeal when we had to support industrial workers who encountered the resistance of their principals.

The following case comes to my mind. The workers of the Kiev tram shops insisted on welding in the manufac-

ture of car frames, but the administration of the shops only waved the importunate welders away, and things remained as they had been.

The workers decided to "wash their dirty linen outside." They came to me, stated the matter, and we submitted this dragged-out controversy to the welding committee. The representatives of the administration would not give in even then. We chose another means: we conducted several experiments in our laboratory and proved the workers were right.

The situation differed somewhat at the Bolshevik plant where welding was appreciated. The plant received a large order to manufacture machines for the sugar-refining industry and used electric welding.

The client bristled up:

"Why did you weld? Who asked you to do it? We won't take the equipment, do as you please with it."

The Bolshevik comrades protested reasonably:

"The technology of production is our business. You can only ask for high-quality work, but that we guarantee."

The client wouldn't hush:

"But it is our business! All you want is to get rid of the machines, but we can't take the risk."

At that time the sugar refineries didn't think very much of welding anyway, and here they were given welded equipment.

A big and noisy controversy ensued. We couldn't keep aloof and joined in. This exasperated the sugar people.

"What is it to you?" they said to us. "This is our departmental issue and we'll settle it ourselves."

But we felt directly concerned with it and, what's more, the matter was of vital interest to us.

I sided resolutely with the Bolshevik and after thoroughly examining the machinery I wrote my firm unconditional decision in favour of welding in the manufacture of the machinery. This settled the issue.

The event gave rise to an interesting undertaking.

The Bolshevik plant had only learned to weld two types of machines, though there were many more. The following idea occurred to me—to publish an album of welded machinery for the sugar-refining industry, which could also be used by other special machine-building plants. There were no ready samples on hand. Engineer Sabbotovsky and I looked through all the types of machines in production, considered what could be welded and how, and subsequently published an album-atlas which I had planned.

Later I chanced to visit plants which manufactured machinery for the sugar-refining and chemical industries and repeatedly ascertained they had increasingly and more confidently had recourse to our album.

Life taught us the old did not easily give way to the new. At times it seemed the old had received a powerful blow and that thenceforth everything would be all right. Nothing doing, old habits are very strong and tenacious. You have to hit hard and consistently for the new to win.

We fought a long battle with the boiler inspectors of the sugar-refining industry.

These people wouldn't give welding its due for anything in the world. At one of the conferences of the boiler inspectors I had a major encounter with them, but was unable to shake them.

I had to chalk up a defeat for myself.

One year had elapsed. A similar conference was called again and much to the displeasure of my adversaries I made my appearance once more. They had to hear some very unpleasant truths from me.

"Remember, Dear Comrades, how we proposed to use welding when the plants were in repair and you would have nothing to do with it, prohibited and anathematized it. Well, what happened? The repairs took way too long and the sugar-refining season began very late. How about

owning up to your mistakes and drawing the necessary conclusions now?"

The facts were against the inspectors and they admitted they had been wrong.

Welding gradually began to take root in the repair work of the sugar-refining plants.

This firm policy, directed at close contact with production, at devoting all of our scientific work to practice, at making life progressive, active and restless, increasingly determined the content of our welding committee's life. Its members were assigned to certain plants where they did their main work. The Kiev welders frequented the committee; industrial engineers corresponded with us and often came to our laboratory for help and counsel from other cities.

The students of the Kiev Power Institute made themselves at home in our committee. They attended a course of lectures and did their practice work in the laboratory; many of them subsequently became welding enthusiasts. Shop foremen, chief engineers and plant directors came ever more often to our committee where we gave them a thorough "going-over."

But get me right. When I say we always longed to do actual work in shops, on construction jobs and railways it doesn't mean we neglected our purpose and calling of a scientific institution. On the contrary, the living practice with its needs gave food to all of our research, while our research, in its turn, paved the way for welding to industry.

How were we, for example, to design welded structures? In this case we could not simply repeat the practice accepted in riveting. We conducted numerous investigations, worked out norms and technical requirements for designing welded structures, and the people in actual work no longer had to use primitive methods or grope in the dark, each after his own fashion.

The "life span" of riveted structures is limited by rigid norms; like man they age, become "decrepit" and go out of commission.

Surely there must be some way of preventing premature old age of structures. Perhaps the steel electrode would prove just the tonic they need? We worked hard on this problem and proved that old bridges, for instance, could be strengthened by welding even without unriveting the separate members and without scaffolding. On the credit side of the ledger—simplicity, low cost and longer bridge life.

Now let us assume that some designer of steel structures acquired faith in welding and, finally, ventured to substitute it for riveting. He has no right to risk the strength of the structure and is immediately faced by numerous questions which he is unable to answer. What types of joints are the most rational for welding? Of what design should the welded beams and their joints be? How should a welded truss differ from a riveted one, etc., etc? I put these questions to myself and Gorbunov, to engineers Varzhitsky and Marchenko. We placed our "answers" on the designers' desks in the form of two books—a monograph *Electric-Welding Structures in Industrial Construction* and an album of similar structures with dozens of drawings.

Who gained the most—science or practice? I believe both gained equally.

In 1932 we received an order from the miners and metallurgists of the Donets Basin. The order introduced several new themes into our plan of scientific work; the themes were very interesting and fascinating to us and of vital importance to the Donets-Basin industry. They gave us a new and strong impetus for searches and experiments.

In those days I chanced to read for the first time the following statement of biologist K. Timiryazev:

"Science is in a hopeless state when it finds itself in the boundless desert of universal indifference. Only by making the whole of society a partner in its interests, by calling on society to share in its fortunes does science acquire an ally and reliable support for further development."

I was strongly impressed by this statement. Yes, we Soviet scientists were very fortunate in having such an ally, such support. That is why we looked and marched ahead with such confidence.

My doubts about the reality of the first five-year plan were completely dispelled at the time.

I was happy to read newspaper reports on the solemn opening of the Dnieproges the construction of which tsarist Russia had contemplated for decades and had never been able to cope with.

Giant plants were being put in operation one after another and I managed to visit some of them. I remember spending a whole day in the spacious and sunlit shops of the Kharkov Tractor plant and standing at the assembly line and up-to-date lathes. But even more than this miracle of engineering that had come into being on these vacant lots I was impressed by the young men and young women who so confidently operated the intricate machinery.

Most of them had come to the plant from the country; they had worked on the plant's construction sites, had dug the foundation pits, carried the bricks, laid the walls and glazed the roofs, froze in the cold barracks and stood in lines for a little thin soup. Now they were operating the precise and ingenuous machinery and making with their own hands powerful tractors for their native villages; they were forging the arms in the struggle for a new life.

Listening to the stories these young people told me about themselves I began to get a better insight into

what I had not formerly realized; deep in my heart I began to feel the young and healthful atmosphere of the socialist epoch which was so unlike that of my own youth.

The country lived and worked with a purpose and the scope of the construction was such as could never have been dreamt of in the old, peasant Russia. The most complicated technical problems were transferred from the world of dreams into the world of reality. Everything was done rapidly and practically, which was quite in keeping with my ideas of life.

Only four years elapsed since the five-year plan had been launched—but a moment in history, and the old, backward Russia was no more, for she had made a lion's jump ahead.

I admitted my mistake honestly: the Bolsheviks, whom I had so very recently considered dreamers and visionaries, could calculate and plan much better than I. It seemed to me I had calculated everything—the money, the metal, the brick, etc.,—everything except the enthusiasm of the Soviet people, except the people's energy and the people's will, cemented and guided by the Party of Communists.

The years of the first five-year plan were decisive in the final formation of my consciousness. Under the influence of the gigantic changes in public life, under the influence of the total reconstruction of the industry and agriculture, which could have been accomplished only by a strong government endowed with great vitality, I disavowed everything that had connected me with the old world outlook. I took sides with the Soviet government wholeheartedly and for good. I had done with all formerly unsettled issues. I now had only one aim—to work for society, for the people.

3. NEW SCOPES

I shall begin with a little history, both remote and recent, which may not be uninteresting to the reader.

At the end of last century, in 1886, the Russian engineer N. Benardos received a patent in Petersburg for the method of electric metal welding discovered by him.

At the basis of his discovery lay the brilliant thought of V. Petrov, one of the most prominent physicists and first Russian electrician, of the possibility of using the heat of the electric-arc discharge for metal melting. Academician Petrov proved his conjecture by numerous experiments and observations.

This idea was far ahead of its time and it required long decades for the engineers fully to utilize it.

The impoverished Poltava landlord Benardos was known as a talented and impassioned inventor, very fond of engineering. But even his inquisitive and daring mind had never created anything so important before then.

Benardos was the first in the world to demonstrate (in Petersburg) metal welding with the aid of an electric arc. The welded object served as one of the poles, the coal pivot—the electrode—as the other.

Benardos did not content himself with this accomplishment but tried to penetrate into the secret of the process taking place in the welding arc. The inventor worked out a method of welding in a stream of protective gas, welding with an arc of direct and indirect action, a method of magnetic arc control, a method of resistance point welding, etc. Benardos' electrodes and their holders were notable for their original design and shape, while his electrode with a core of various powders is still used in our time. Benardos also proved the possibility of welding under water.

It should be recalled that all this happened nearly 70 years ago.

The entire world had to acknowledge the priority and services of Russia in one of the greatest technical discoveries. Benardos was given a patent for his method of "joining and disjoining metal by the direct action of electric current" in all the industrial countries of Europe and in the U.S.A.

Only a few years had elapsed and a new epoch in the history of electric welding was opened. The new epoch is connected with the name of N. Slavyanov, Russian mining engineer.

The "electric founding of metals," proposed by Slavyanov, who was manager of the Perm Steel and Cannon Plant, came into wide use in repairing large parts and defective articles. The steel electrode welded cracks in the side plates of gun-carriages, blisters in the casts of gun tubes, and fused metal on the worn-out parts of machinery. It was no longer necessary to send the defective parts back to the furnace for smelting. Slavyanov and his pupils "treated" them with their miraculous rod and restored them to life.

At the Perm plant Slavyanov set up the first and only welding shop of the time and taught the first school of welders.

These successes alone were enough to place Slavyanov in the front ranks of the Russian and world engineers.

But the manager of the Urals plant looked much farther ahead. A well-educated and competent engineer, he was persistently searching for ways and means of controlling the metallurgical process of welding, and he proved the process could be controlled.

This remarkable person was possessed of a wonderful scientific intuition and sagacity; the ideas he had voiced are still feeding our thought and are being elaborated in Soviet and world science.

Neither Slavyanov nor his outstanding work, however, could be justly appreciated in Russia of that time, and

the industry was extremely slow in taking up his ideas. At one time Slavyanov attracted attention with his proposal to repair the famous Tsar-Bell in the Kremlin by means of electric welding. But the powers that be looked askance at Slavyanov's "innovations" and soon lost interest in him again.

An exceptionally important invention remained a personal affair of a Urals' engineer. He had patented it in many countries, received a diploma and a gold medal at the World's Fair in Chicago in 1893, but even the official recognition of Slavyanov's services abroad failed to impress the tsarist officials. They had learned once and for all that only the inventions, which were imported to Russia from abroad, were worth while.

It required the victory of Soviet power in Russia to bring the inventions of Benardos and Slavyanov, like many other discoveries of talented Russians, into the light of day and to make them really serve the people.

As early as the twenties, when the Soviet industry was rising from the ruins and beginning to develop, welders made their appearance in hundreds of shops. The necessary machinery—welding transformers and generators—were being manufactured at a fast rate.

A young and powerful industry was being born in the country, and welding developed apace. In 1930 there were already tens of thousands of welding posts in the U.S.S.R.; soon their number considerably increased.

The first five-year plan gave a powerful impetus to the development of electric welding; during those years welding already successfully competed with riveting on the construction sites of Magnitogorsk and Kuznetsk.

We felt the rapid development of electric welding on ourselves: the plants and construction jobs posed before our laboratory ever new questions which we could not very well answer ourselves.

It was plain to the Academy that we could no longer continue in the old manner and we were met halfway in all of our undertakings. We were given additional light premises, our allocations were considerably increased and our laboratory acquired new equipment. But all these were only half-measures and solved our problems only temporarily. We felt somewhat crowded within the framework of the laboratory and the electric-welding committee; the nature of their activities was becoming so universal and the scope of their work expanded so much that life itself forced us to search for new and more perfect forms of scientific endeavour.

I thought the time quite ripe for founding a special scientific-research institute of welding.

As is often the case the birth of something new gives rise to scepticism and criticism. Some academicians said to me:

"Isn't it too narrow a field for a whole scientific institute?"

"There isn't a single institute like that in the country. It's a bit too far-fetched."

I knew very well why our science and industry needed such an institute and was not at all disconcerted that the institute had had no predecessor. We were not going to build it out of thin air, for we had already had three years of experience in the laboratory of the Academy of Sciences and in the electric-welding committee.

The idea of creating an institute had in addition to critics also ardent friends and defenders. All, who were vitally interested in the development of electric welding, defended it. The voice of the Republican conference of welders (held in Kharkov in May, 1932), sounded in support of this idea, carried a lot of weight.

It was about the same time I met the new President of the Ukrainian Academy of Sciences—A. Bogomolets, a talented scientist and a wonderful man. All we were

doing was very far from the field in which he worked, but he immediately grasped and appreciated the idea.

"Your undertaking is very much worth while," said Bogomolets after listening to me. "I'm ready to give it my full support, and I think the entire Presidium will be behind you. But, apparently, our decision won't suffice? You need money to put up the institute building, don't you?"

"Certainly," I affirmed. "But we understand that now, when so much is being built, every ruble counts; we could, therefore, do with a very modest sum as long as it suffices to put up a building. As far as the equipment is concerned, we will earn it ourselves on the contracts with the plants."

Bogomolets kept his promise to support us with his usual enthusiasm. The Presidium of the Academy of Sciences approved our idea and immediately appealed to the Ukrainian Government. The rest occurred with unexpected speed. In June the Government adopted a decision to erect a building for the Institute of Electric Welding and to begin with appropriated 200,000 rubles. Later this sum was nearly doubled.

When I deliberated on what the institute we were creating was to be like, what methods and style of work we were to adopt and what mistakes we should prevent, I tried to make more intelligible to myself my work in the electric-welding committee, on the one hand, and at the Kiev bridge-testing station, on the other. The former gave us positive and very valuable experience, the latter—an object-lesson for the future.

I had worked at this bridge-testing station for nearly ten years. Outwardly everything was all right. The scientific and technical committee of the People's Commissariat of Railways, to which this and two other stations were subordinate, sent us an annual work plan, i.e., a list of bridges to be tested. In the summer I worked on the

bridges with my associates, the undergraduate and graduating students of the Polytechnical Institute; in winter we summed up the results of the tests, drew up reports and sent them to the People's Commissariat and the Railway Departments.

In ten years the station had tested about 150 bridges in the Ukraine, Byelorussia, the Volga Country, Kazakhstan, etc. The result seemed quite impressive, but the trouble was that these tests, made at all the stations of the scientific and technical committee, were of a routine nature and in time degenerated into a simple formality. We were asked to make endless measurements of a kind, which was of no practical importance.

As time wore on I realized the uselessness of this work. I stated my views time and again at the meetings of the committee in the People's Commissariat, but my "seditious" words were simply disregarded.

In spite of this I did not want to give up my work at the station because I had been interested in bridge-testing ever since my student days and had never lost my love for it. At our own responsibility we began to investigate rather serious matters.

Our work had not been in vain, for the results of many of our "out-of-plan" tests and measurements were later included in my textbooks and scientific papers. We were doing this work of our own accord, apart from our duties at the station, and the work only emphasized the futility of our daily efforts.

At last, the Kiev station was closed down in 1930; this was followed by the closing down of the two other stations as well as the scientific-technical committee. Recalling their ignominious end two years later I asked myself what the fruits of their activities had been. That was no idle question at all, for I wanted to learn a useful lesson from the sad lot of these stations.

Well, the station workers, including ourselves, had

worked hard, had spoiled a lot of paper, had spent many months on wheels, had drawn up innumerable diagrams, had published a considerable number of books containing the results of our work, had spent piles of money on fares, instruments and wages...

Any use?

Hand on heart we had to admit there was hardly any; there were scarcely any tangible results.

These stations had the same fate as some other scientific-research institutes which had never produced anything worth while. At that time I saw similar things happen also in some research institutions of the Academy. Their people seemed to be doing something, writing something; they maintained the appearance of an active scientific life, but it only covered up a void and concealed the aimlessness and futility of their work.

I vowed never to make the mistakes of the bridge-testing station at the Electric-Welding Institute of the Academy of Sciences.

4. FIRST STEPS

In the beginning the department of welded structures was the principal department of the institute. It was rightfully headed by Gorbunov, who in the laboratory of the Academy had always devoted all his time to welded structures. That was the work he loved most. Gorbunov had long since been attracted by theoretical problems and worked on various intricate calculations with special zeal and pleasure.

A serious scientist with profound knowledge but with a somewhat "academic" turn of mind, he could let himself be carried away by abstract problems, whereas I preferred theoretical themes that could find practical application. I participated directly in the work of this department, and Gorbunov and I made a good team.

The department continued the tests of the strength of structures, we had begun earlier, on an even larger scale. We frequently received threshing-machines, combine chassis, trucks of Pullman cars or bridge girders, etc.

The first big work of the department of welded structures was an experimental research of welded girders subjected to plastic deformation under repeated load.

Abroad, in Germany, for example, these experiments were conducted on small laboratory models, whereas we tested real structures under conditions which approximated the real. Experimental data confirmed that the method of calculation, we had proposed, made it possible to lighten certain members of the structures, such as girders and chassis, and yielded considerable economy of metal.

This problem caused a great deal of controversy.

One day, at an all-Union conference of welders I happened to meet a foreign guest—a big German specialist—and had a sharp discussion with him. I cited facts, results of experiments, but the guest regarded them with scorn and even with irony.

"I have great doubts as to the inferences Mr. Paton makes from his research work. At any rate, I am sure they will yield nothing real in practice. The prevailing opinion in Germany is that welding won't do for vibrational loads."

Everyone at the conference retained his own ideas; I, personally, returned to Kiev and resumed my research work on an even larger scale.

We endeavoured to find the best types of welded joints and to make them as strong as possible under vibration. We conducted experiments that should have convinced the most inveterate sceptics.

For instance, in order to compare the vibrational strength of welded and riveted structures we tested to the point of destruction two equal-size bridge span-struc-

tures—one welded and one riveted, specially manufactured for us at the Bolshevik plant.

All of the inferences spoke in favour of the welded structure, and I was sorry I could not acquaint my German critic with them.

Our institute was just beginning to live, but the practical welders would not reckon with our age and would not make any allowances for it; they demanded direct answers to their vital questions and gave us very little time at that.

The problem of preventing the shrinkage stresses and deformations, caused in welding by the local heating of the metal, was the most urgent and, at the same time, one of the most important theoretical and practical problems of welding.

These phenomena, which have not been fully investigated to date, were a veritable scourge of welding. Trusses, girders and pillars, gracefully drawn by the designer's pencil, not infrequently acquired the most fantastic and unexpected shape.

I appointed a group of young institute workers to study this problem. They conducted extensive painstaking theoretical and experimental work for the purpose of determining the nature of shrinkage stresses and welding deformations and their influence on the strength and durability of structures. Soon we were able to recommend the industry certain real means for preventing these phenomena and to warn against pseudo-innovatory and more than doubtful methods practised until then in certain plants.

To be sure, it took many more years before Soviet welding science was able to answer all these sharp questions. We are still working hard at our institute and in other scientific institutions of the country.

Cracks in the welded seams gave us no end of trouble.

We were showered with complaints and questions every time we visited some plant.

"These damned cracks will be the death of us. How can we get rid of them?"

"We've tried everything, but it's no use. Have you thought of anything at the institute?"

I felt quite ill at ease when I was unable to advise them right there and then.

First of all we had to find the reasons for those cracks ourselves. We searched for a long time, made mistakes and muddled things up, but were finally able to ascertain the reasons for the cracks both in the seams and in the welded metal. It is easier to cure a disease when the causes are known.

We were no longer ashamed to look the factory welders in the eye. They literally caught our methods of crack prevention on the fly. These were, of course, only the first steps. In the nearly two decades that have elapsed since then we, as well as other welding scientists, have made considerable headway, but in any modern book dealing with methods of preventing cracks one can find references to what the institute had done at the time of its infancy.

Those, whom I criticized and reproved in my speeches and articles in the beginning of the 30's for their neglect of welding, hardly suspected I was also the strictest critic of welding.

But it doesn't seem to make any sense. Boosting and criticizing welding at the same time? And still there was no contradiction there. Let me explain.

What was it about welding, or rather the state it was in at the time, I didn't like? I hope the reader does not find my answer strange if I say that I disliked one and the same thing about welding and riveting. I did not like electric-arc welding because it was a slow and manual process.

But wasn't welding an enormous stride ahead? Sure it was, but compared with what? With riveting! Yet I wanted to compare it, and did compare it with something else, namely, with the tremendous possibilities concealed in the very idea of using the electric arc for joining metals, with the as yet scarcely utilized power hidden in the arc.

I had been struck by this contradiction at about the time I had started working on welding, for I realized that although it was the most advanced and most productive method of inseparably joining the metals, in practice the speed of welding did not exceed 3-4 metres per hour. Like in Slavyanov's time, the welder continued to operate the electrode manually, extending the seam slowly drop by drop.

I protested heart and soul against this technical imperfection. It was the same as making Hercules wield a thin little switch.

Visiting the plants in 1930-32 I often stopped near welders and watched them work. Manual welders are highly skilled workers. It takes a great deal of painstaking work to train them. After training they get diplomas and then from time to time they undergo strict tests to see if they haven't lost their skill. Various safety and labour-protection measures and devices are used in industry for the welder, but he works under difficult conditions nonetheless. He frequently has to work in an inconvenient posture, bent over and sometimes completely hunched up. A heavy tarpaulin suit and a shield or helmet with dark glasses protect him against the blinding light of the arc and the fiery sparks of the metal, but hamper his movements. However good the ventilation in the welding shop may be, the harmful hot gases render breathing difficult and sometimes quite impossible.

Without taking his hand with the electrode off the thing he is welding the worker must constantly and closely

watch all his movements since the arc must be constantly kept at an equal distance from the seam.

The quality of the seam and the strength and reliability of the structure depend on the welder's skill, his attentiveness, his endurance and even his mood. The welder is forced to take frequent rests, but his arms, eyes and back tire just the same. Small wonder that by the middle of the day his movements slow down, his attention weakens, while the quality and uniformity of the seam deteriorate.

I looked on and wondered each time: how hard manual labour is and how low its productivity in comparison with what electric welding could and might yield under the conditions of modern engineering.

The situation was rather complicated. We were fighting for the spread of welding as it was, and it were we, too, who realized better than anybody else its major defects. I myself could not and would not put up with it. As early as 1930 we began to feel the only way out was in the mechanization of welding. Only mechanization was able to bring about a sharp increase in the productivity of labour. The hand of the welder was to be replaced by a perfectly running automatic machine only controlled and guided by man.

What happens in welding? Under the influence of the heat of the electric discharge the electrode's end constantly melts and the liquid metal passes into the seam. Hence, the electrode must be continuously moved towards the metal, for the arc must not be allowed either to lengthen or shorten. This is the principal part of the manual welder's skill. Was it impossible then to build an automaton capable of maintaining the arc and controlling the melting of the metal with the same sensitivity?

This question had been answered in the main many years previously by Benardos and Slavyanov.

Designs of machines for the automatic welding of different metal objects were found among the papers of Be-

nardos. To think what the inventor had contemplated doing at that time! In Slavyanov's experiments the electrode was moved to the spot being welded by a special device he had named the electric melter.

Our famous predecessors blessed us, as it were, for new exploits and equipped us with their daring thoughts and experiments. A department for mechanizing the welding processes was established at our institute from the very first days of its existence.

We worked in several directions, and the department included two groups at first—the group of automatic welding with a metal electrode and the group of atomic-hydrogen and carbon-arc welding. The group of resistance welding made its appearance later.

Each of these groups followed its own direction and had its own fate.

The atomic-hydrogen welding group gave us little reason for rejoicing. The group suffered from a chronic disease—a desire to work under hot-house conditions of a laboratory on ideally prepared samples. No wonder all its "achievements" burst like bubbles at the first contact with real life. In addition, the group was at first composed of . . . one person, who, besides, worked very slowly.

Perhaps the greatest "imprint" this group has left in the history of our institute was the explosion, which occurred during one of the experiments and which, to the big delight of the boys of our street, blew the roof of the laboratory off (the experiments were conducted in a small annex) and carried it into the neighbouring yard.

The work of the resistance-welding group was of a more serious nature. At that time our industry had very few resistance machines and the enterprises wanted the institute to build them as fast as possible, whereas we had to begin with the ABC's.

This group immediately attacked the practical problems of industry and began to design machinery for the

various types of resistance welding of carriages and rails, to elaborate the technology and to investigate important problems. But the attempts of this group to automatize every process failed. The first machine, designed by this group, was never finished, while the second machine, apparently, made no appeal to the industry and was not accepted.

Why did we fail also in these endeavours? The trouble was that this group, too, was only composed of three persons, two of whom had but recently been students. The institute did not have enough people and, what's more, it scattered them. Nor was our shop equal to the task of manufacturing complex resistance machines at the time.

The group of automatic welding with a metal electrode came more and more to the forefront. The future showed that this type of welding lay in the main direction of our work.

From the welding laboratory this group received a precious inheritance: our first automatic head—the direct "descendant" of Slavyanov's electric melter.

Similar machines made their appearance abroad, but they were uncommonly intricate and not dependable enough.

Our original automaton performed all of the operations the welder did by hand: it ignited the arc, maintained its constant length and tension, moved the wire to the welding zone and filled the crater at the end of the seam. The movement of the head along the welded object was mechanized. It vividly demonstrated its advantages: its productivity was three times that of manual welding.

We, naturally, realized we were just making a start, that we would have to face dozens of dreadfully vague and complicated problems and that the automatic head we had invented was far from perfect. Incidentally, it was subject to many attacks, both fair and unfair. We careful-

ly heeded the former, and rejected the latter, but never gave our invention up.

The Ukrainian Autogenous Trust sided with us and ordered from one of the Kiev trade schools one hundred welding heads of the type proposed by the institute. The trust rightfully believed they would best be tested in the shops, at the working places. This test would disclose the strong as well as the weak points of the machine.

True, only one batch of the heads was manufactured after the drawings of the initial model. That is quite natural, since we continuously worked on the problem of simplifying the design so that any welder of average skill might be able to adjust and operate it. The first model was followed by the second, then the third. For the benefit of those, who called for foreign-made heads, we could now show the convincing results of the tests at the Gorky Automobile Plant. There were many foreign-made heads of different systems, but the comparative tests demonstrated the advantages of the head produced by our institute. Besides, it welded thin metal at the rate of 100 metres per hour. This model was recognized as the best head; it took root in practice and existed up to the time of the Great Patriotic War.

We were not the only people in the country who worked on designing welding heads; the Leningrad Electric plant also made a considerable contribution to welding. But that was a plant and not a scientific institute; it was an electro-technical plant and we could not demand that it pay as much attention to welding machinery and the technology of welding as it did to the heads.

No, we could not make any demands on the plant, but industry could and should make them on us. We therefore tried to solve all our problems in a complex manner.

Now we could no longer do with two or three designers in the department of mechanization. We needed a self-

dependent and strong designing bureau capable of daring and solving the problems in its own way. Outside that we could not possibly dream of building more perfect machinery, devices or apparatus.

I was a long time finding the right man to head this bureau. The man, who was finally placed at the head, was L. Sevbo, a mechanical engineer with extensive experience, a thoughtful and serious person who could be depended upon.

Investing Sevbo with authority I said to him very frankly:

"It will be hard. There is a lot of work and scarcely any experience. I am attaching great importance to your bureau for it will depend on the bureau whether we'll be able to implant automatic welding in industry. You won't be able to do much with the staff you now have, so expand your bureau, find yourself the people you need."

The difficulties did not frighten Sevbo; he set to work with zeal, but did not heed my advice in the beginning and continued to work with the same small staff.

I reproached him for it and warned him the bureau might easily become the weak point of the institute. Sevbo had his own ideas.

"Don't you see, Comrade Paton, I can't find any good designers for our work. Nobody knows anything about welding."

"But you did not know anything about it before either," I objected. "There are surely no ready-made men for our bureau, but then you can't expect them to fall from the moon. Take young, recently graduated mechanics and engineers and teach them while they're working. Hard? Yes, but there's no other way out."

It was not so easy to prevail upon Sevbo, but as soon as he believed me right the designing bureau began to employ more and more talented young people. It was a matter of "sink or swim" at first, the novices doubted

their own abilities; in time, however, they acquired knowledge and assurance.

The department made mistakes and met with many failures in its work, but it also had its accomplishments. Our first automatic-welding machines were cumbersome and hard to work with. We did the best we could to lend them an industrial appearance.

But if you put a gigantic portal-welding machine with powerful columns, most intricately interweaving rack-wheels, shafts and fly-wheels, next to a small, graceful self-propelled welding-head and say that these "mountain" and "mole-hill" perform the same functions, you will immediately agree that our time had not been spent in vain. 180 working designs of machines for the electric welding of girders, columns, cisterns, carriages, boilers, etc., plus some original apparatus was nothing to sneeze at.

Heads... Machines... Apparatus... There is nothing of the sort in manual welding. But, then, what is the electrode wire to be like? Must it differ in any way in automatic welding? At first we tried bare wire, but immediately got ourselves into a lot of trouble: the arc burned unsteadily and the mechanical properties of the seam could satisfy neither us nor the plants. We racked our brains to get rid of the influence of magnetic fields, tried out all sorts of intricate devices to create a compensating magnetic field, but alas!—it was all of no avail.

The problem required radical solution. We searched for something to cover the wire with in order to steady the burning of the arc.

A chalk coating is used for this purpose in manual welding, but as our numerous experiments showed it was no use for automata. We conducted a series of experiments and were soon able to offer three new types of quality coating. We also designed special machinery for the manufacture of the heavy-coated electrode wire. The

new coatings were a considerable improvement over the old ones.

We were now in a position to strike a balance. We had a dependable welding head, we established the requirements for the chemical composition of the wire, a stabilizing coating for the wire was found, the technology of automatic welding was in the main elaborated and tested, the designing bureau got on its feet and was successfully designing machinery for welding various objects. We could consider the problem of automatic welding solved by the institute. This was acknowledged by an order of the People's Commissar of Heavy Industry in May, 1936. As the director of the institute I received an official expression of gratitude in the order. Our work was also noted in flattering language at the conference on automatic welding, held in Kiev the same year. Last, but not least, our welding machines made their appearance and began to operate in several plants.

It looked as if all we had to do was to rejoice and if we were not to rest on our laurels, we could at least content ourselves with simply developing and perfecting what we had discovered. As a matter of fact, though, we had not reached our goal by a long shot. And then life itself intervened in our affairs and plans.

5. INSTITUTE COMPETES WITH STAKHANOVITES

In the beginning of September 1935 our country learned the name of Alexei Stakhanov, until then a totally unknown coal-hewer from the Central-Irmino Mine in the Donets Basin.

All former ideas of the productivity of labour were upset at once. The very first spark flamed up with amazing speed and followers of Alexei Stakhanov appeared in hundreds and thousands of plants, factories, mines and

on collective-farm fields. Since then his own records were beaten by other miners many times.

I felt something new and very important was being born in our country, in our life. I carefully watched the newspaper reports and never doubted that we would soon hear the names of Stakhanovites-welders. This is precisely what very soon happened. While the records of steel founders, blacksmiths or weavers made me happy, as they did every Soviet person, in this case a feeling of special personal interest was added.

I read of Stakhanovites-welders who were exceeding the former norms; the newspapers cited figures that superseded our old and customary ideas of the possibilities of manual welding.

"Could this possibly have been accomplished by merely a better organization of labour and a fuller utilization of the working time?" I wondered. "Incredible. These advanced workers must have some new production methods of their own, some essential corrections in the former methods of using the welding machinery."

The first newspaper reports carried little details. I decided to arrange a meeting of our institute workers with the Kiev Stakhanovites-welders in order that we learn the best methods of work from them.

Our guests were welders from the South-Western Railway. They were noticeably embarrassed as they entered the conference hall; it was the first time they had crossed the threshold of a scientific-research institute. Such meetings were still a novelty at the time.

Opening the conference I directly addressed the Stakhanovites:

"In the past, comrades, we usually visited the plants and shops where we were asked dozens of questions. We hope to be useful to you in the future as well. But today we have to change roles. This time we will do the asking. Today we are not teachers, but pupils. And, please, com-

rades, we want no timidity before the big name of our institute; it is high time the scientists learned from you, the advanced men of practice."

These words, apparently, produced an effect. One after another our guests mounted the rostrum, and in their speeches one could no longer discern even a trace of the former embarrassment or timidity before the workers of the institute and the city welding engineers whom we had also called to the meeting.

The very first statements, made by the Stakhanovites, confirmed my conjectures that they had attained their records not only by a better organization of their work and their working places.

"It's all a matter of boosting the current, that's all!" the welder of the Kiev locomotive-repair plant stated with confidence. "You run it up to 400 amperes and your output is doubled."

"That's a perfectly good idea," I remarked, "but how do you do it?"

"There is only one way about it," the Stakhanovite replied. "We use heavier electrodes, one and a half times as heavy as the usual ones. The idea does not appear very ingenious, but the results are remarkable."

I never for a moment let the pencil out of my hand and wrote down all that was of any interest. It turned out that all Stakhanovites had chosen the same method, namely, a bold boost in the current tension. Each tried and sought independently, but they had all come to the same thing.

I took notes and thought it was only along that path that we could forge ahead. Else...

And as though giving form to my thought the welder from the Kiev depot spoke directly to me:

"No hard feelings, Comrade Paton, but as long as we are here, let me tell you frankly, as a worker: there are only few of us yet who can produce double the norm. But

tomorrow there will be hundreds, perhaps thousands. We may even catch up with your automata and then, who knows, we may even outstrip them. Our scientists would do well to think this over, while there is still time..."

I was the first to applaud this man and was followed by the others. The man had put it right and in very certain terms.

This meeting with the Stakhanovites gave me serious food for thought.

It was clear—automatic welding was in for it. I had worried even before then that only a small number of our welding heads were used in the shops. Many of them had been kept in storerooms; the industry accepted them but slowly; there were very few automata in operation.

We knew certain industrial leaders refused to build intricate and expensive machinery, preferring to replace them with several manual welders. I said to my colleagues:

"Who will have any use for our machines if a single Stakhanovite can replace an automaton?"

"But automatic welding has its incontestable advantages, and primarily, higher quality of the seam and facilitation of work," they objected.

"This is right, of course, but its other advantage—higher productivity—has been or soon will be lost. Why shut our eyes on facts? The electrode in the hands of a Stakhanovite is becoming a serious competitor of the automation."

In confidential talks with my colleagues and at institute meetings I kept saying:

"We have to make a choice: either we give up and acknowledge our defeat or we go into open competition with the Stakhanovites."

My anxiety was communicated to many of my colleagues, but not all of them realized how acute the situation was.

Some short-sighted people solaced themselves by the fact that there was really nothing to worry about as long as the quality of seams was on our side. They deluded themselves with the idea that the Stakhanovites had reached their limit while everything still lay ahead for automatic welding.

I called these people "slow-pokes" right to their faces and warned them frankly:

"Indifference, or turning a deaf ear to the signals of life may cost us a great deal. Is it only the privilege of Stakhanovites to work with a larger-diametre electrodes and a greater current tension? Why can't the automaton weld in a 'Stakhanov-like manner'?"

At the same time life posed another complicated problem before us. The factories, which were producing important apparatus calculated for high pressure, insistently demanded that the mechanical qualities of the seams be improved and that some method be found to do it.

Manual welding immediately responded to this demand. Soviet scientists supplied manual welding with electrodes with high-grade coatings which made it possible to boost the tension of the welding current.

It seemed manual welders were beating us also in this case, while we couldn't even hope to satisfy the just demands of industry by practising our usual methods of automatic welding with bare wire or stabilizing coatings alone.

The aim, which cropped up before our scientific staff, I formulated as follows:

"We must simultaneously solve a two-in-one problem: sharply boost the tension of the welding current and produce an electrode wire with a high-grade heavy coating for our automata. We must realize that adherence to our old views hinders our progress. Our only salvation is in rejecting them and learning to think differently."

After that we conducted all-round, complicated research work and, for the first time, doubled the current tension—to 500 amperes—and used electrodes with an 8-10-mm. diameter, something we had never done before.

At last I saw real prospects for progress.

But new and seemingly insurmountable difficulties arose.

How were we to feed the current to the heavy-coated wire?

We all racked our brains over that. In manual welding this problem is solved very easily; there the end of the electrode is left uncoated. But in the automaton the wire is constantly fed from the coil.

I can hardly enumerate all the ways and means we had tried. Only after long trials and tribulations did we finally make our first strike. The wire heated by electricity was rolled in a special machine, where it acquired a cruciform profile, and then was coated in another machine. The four protruding ribs of the wire ensured the constant feed of the welding current. The cruciform wire made it possible to weld with a current of 350-450 amperes with an electrode 6 mm. in diameter. That was a great step forward. This type of wire was accepted by several major enterprises, including the Bezhitsk Carriage-Building Plant. The institute elaborated for that plant the complete technological process of automatic welding of cisterns, the designs of all necessary machinery and the assembly line in all operations up to water-testing of 50-ton cisterns.

Our competition with the Stakhanovites continued. The innovators caught up with us and spurred us on, while we tried to squeeze all we could out of our automata and to "break off from our rivals."

Sometimes we changed roles: the Stakhanovites trod the path first, while we had to catch up with them. The advanced manual welders, for example, could already

work with electrodes 10 mm. in diameter, whereas such diameters were out of our reach. Yet there was a crying need for it because the plants were now beginning to weld increasingly heavy sheets of metal. Manual welding offered no particular complications, whereas we had our difficulties because it was hard to coil wire with a diameter of over 6 mm.

We tried another approach—weld with long, thick-rod electrodes. We seemed to achieve our aim: we welded three to four times as fast. But, alas!—our victory was deceptive. The tests of seam quality disappointed us and we could not recommend our rods for welding important structures.

Much to our regret we had to admit to ourselves that no further increase in the productivity of automatic welding with an open arc by boosting the current was possible. In this direction we had exhausted all our possibilities.

The realization that we had reached a sort of limit worried me very much. I could neither delude nor console myself that everything appeared satisfactory. I was told:

"No one is criticizing the institute; on the contrary, it is being praised. The People's Commissariats and the Presidium of the Ukrainian Academy of Sciences spoke favourably of the institute; besides, we have contracts with a number of plants. It's not so bad at that."

But I could see ourselves running into a blind alley, though we had had years of constant research and experimentation. I did not in any way feel we had worked in vain. I knew intuitively that we would subsequently make use of all the accumulated experience. But what was this "subsequently"?

I repeatedly told my pupils who shared my anxiety:

"In our attempts to boost the current we reached a point beyond which we lose in quality all we have gained in productivity. We all admit it. But if we can't make any headway on our old course we must abandon it and find

a new path. But where is it? That's something we don't know and yet must."

To myself I thought: "Will life give us time to discover the right way in the unhurried rhythm of the work of an academic scientific institution?"

I was not sure.

Something I had feared above all else soon came to pass. It was a very unpleasant incident.

There arose the danger that life would simply sidetrack us.

In 1938 the carriage-building plant in Nizhny Tagil asked us to design a machine and elaborate the technology of automatic welding for longitudinal beams of large trucks. Everyone at the institute was happy with, and proud of the request.

"That means we have won recognition way beyond the Ukraine; we are known and we inspire faith."

It gave me joy to receive an order from one of the major plants which had the most up-to-date equipment. Manual welding was very widely used at that plant, and here was our chance to supplant it with welding automata.

A tempting problem.

Everyone at the institute liked the design of the machine, executed by our designers in the shortest possible time. We hoped the Urals carriage-builders would also like it. In forwarding the drawings and instructions on the technology of welding I asked them to inform me of the performance of the machine. We waited for weeks and months, but there was not a word from the plant.

This silence began to worry me. I felt there was something wrong. Too much time had passed.

I could contain myself no longer and wrote to the plant again.

We learned from the reply that the drawings for our machine were outdated before they had reached the Urals.

Our clients wrote:

"The ten-metre-per-hour welding speed, envisaged by the design, will no longer do. While the plant was corresponding with the institute, while you were working on the drawings, the Stakhanovites-welders at our plant beat the future institute automaton 2:1."

After some deliberation the plant decided there was no sense in so slow a machine.

In the same letter the Urals workers informed us of Silin, their Stakhanovite. Silin was the first at the plant to use an inclined electrode in welding, thus burying our design without in the least being aware of it himself.

The plant did not reject its friendship with the institute. Moreover, it asked us to build a machine with a speed two-three times greater than the one formerly proposed. If we agreed the plant would sign a new contract with the institute.

The letter stunned me.

It was a bitter, very bitter, but well-deserved lesson.

I read the letter several times and felt very much ashamed. It was very hard to swallow this pill, but there was no getting away from the truth. Our clients were right and it was up to us to find out what was what.

A totally unknown Urals worker and a special scientific-research institute had engaged in private competition. Life itself was the referee. The Stakhanovite won, primarily, because he had been in closer contact with life and had been able to adapt himself faster to its requirements.

True enough, his victory was predetermined by the development of the Soviet welding science and the Stakhanov movement as a whole. Incidentally, I did not consider the method, chosen by Silin (the inclined electrode), the most successful. I was still convinced that only the fullest possible mechanization of electric welding would bring us the decisive victory.

But facts were facts: the success of Silin and his comrades at different plants was nothing but a direct criticism of our backwardness. That meant me, too. Enough of "quality-first-speed-and-productivity-will-come-in-time" excuses. . .

6. ON THE RIGHT TRACK

Once again I examined the different ways we had travelled. We had not known a single day of rest; we searched, experimented and tried to learn from men of practice, but all to no avail.

I finally concluded that in our fight for a higher productivity of electric welding we often dissipated our efforts on minor, private problems.

"But what is the main problem?"

"We need a welding current of thousands, rather than of hundreds of amperes. Only then will we be able sharply to raise the productivity of our automata."

But to feed such current to the very end of the electrode wire we had to free the wire of the coating.

Bitter controversies and discussions flared up at the institute:

"Back to uncoated wire? But won't it be a retreat from what we have already achieved?"

"No it won't. The idea is right in principle. But if we give up the coating where will we get other protection against the air and metal sparks?"

"Precisely! And that's just the stumbling-block the manual welders will not be able to avoid when they try to boost the current above 500 amperes."

"How are we to get out of this vicious circle then? The higher the current the more sparks."

I must remind the reader that one of the chief purposes of the coating is to protect the melted metal against

the air. Until then we were wont to consider the coating of the electrode the only protective means.

Everyone at the institute was now concerned with the only problem:

"Was there another means of protection against the air, which would make it possible to leave the wire uncoated?"

We did not have to search for this means long. It was important to get on the right track. Our collective thought was now concentrated, working in the requisite direction and with a clearness of purpose. We went from one version to another and finally recalled the experiments of our compatriots Benardos and Slavyanov, the inventors of electric welding, their experiments with broken glass and the idea of slag protection for the welding arc.

Like everything truly great this idea is amazingly simple.

At the very beginning of electric welding Benardos, and later Slavyanov, noted that in order to obtain plastic melted metal it was necessary to protect it with a slag coat and use deoxidizers, for example, silicium or manganese. Even in his book *Electric Casting of Metals*, published in 1892, Slavyanov directly advised to cover the zone of welding with ground glass, i.e., silicate and ferro-alloys.

Slavyanov advanced this remarkable idea and was the first to demonstrate its exceptional value in practice. In conducting his experiments the scientist dipped the metal arc in a layer of ground glass, which was the prototype of the modern welding-flux.

The information amazed me. Slavyanov had given science nearly 50 years ago what we were so eagerly looking for now.

The institute workers asked me:

"Is it possible that an outstanding discovery was shelved for decades and nobody made use of Slavyanov's idea?"

"It is hard to believe. We must try and find it," I answered.

We soon found indications in literature that Dulchevsky, Slavyanov's pupil and one of Soviet oldest inventors in the field of welding, had successfully continued his teacher's experiments as far back as 1923.

Working on the transport Dulchevsky wondered if electric welding could be used in locomotive-boiler repairs. At that time they were manufactured of red copper; electric arc welding with a copper electrode was considered impossible both abroad and in our country. Acetylene-oxygen welding was used instead. Dulchevsky would not reckon with it. He covered the arc, which was burning between a copper electrode and a similar article, with a layer of coal-dust and isolated the entire melting space from the harmful action of the air. The effect was excellent; the vitality and practical value of Slavyanov's ideas were proved once again. In 1929 Dulchevsky received a patent for his work.

We had groped in the dark for quite some time before finally turning to Slavyanov's brilliant idea, at last finding the key to the problem, which had so long tormented us. We were now ready to take the last decisive step. Obviously, our former work on automatic electric welding had not been in vain; we lacked only the last, finishing, though to be sure, very important touch.

The task we were now facing was really difficult and complicated.

New life began at the institute. The idea of creating a method of automatic welding under a layer of flux impressed everybody. The lucidity of the perspective and the clear understanding of the aim of our scientific work inspired us and gave us strength and courage.

At the end of the summer of 1939, a group of workers, I had chosen with particular care, launched its first laboratory experiments. Dyatlov had headed our department of technology since 1935. He was a well-educated and

energetic man, a talented scientist and a great specialist in the metallurgy of welding. He soon won the authority and respect at the institute by his profound and frequently original approach to each research problem. Lapin, also an expert in the metallurgy of welding, had good knowledge in the field of blast-furnace slags. It was very important to the success of the work we had undertaken. Shirin, the laboratory assistant, with his long experience in welding, resourcefulness and ability quickly to solve complicated technical problems was also a valuable person in the group.

These men had always put their heart and soul into the work, but now even they were beyond recognition.

They stayed at the institute after hours. Their wives grumbled at first, but soon had to reconcile themselves to the fact that their husbands "had strayed away from home" and that their "lords and masters" deserted them on Sundays and went to their comrades to prepare new calculations and experiments.

"Is it true you've given up your shotgun?" I once asked Dyatlov, who was known as a passionate and inveterate hunter.

"To the devil with the shotgun if I can't get hold of that confounded flux," he waved his hand.

In our search for the flux we began with the most elementary things.

Slavyanov recommended glass and we followed **his** advice. We smashed an ordinary bottle, thoroughly ground it into a powder, covered the welding spot and switched on the welding head.

We did get a seam, but what seam! It was rough and uneven, full of pores and blisters. We were, certainly, dissatisfied.

It meant that glass alone wouldn't do. What were we to add then? No one had a ready-made answer. We resumed our search.

The work, we had done in the recent past on high-grade electrodes, now came in handy. At the outset we groped in the dark, and the most primitive methods and "intuition" reigned in the choice of the coatings.

This "scientific quackery" could not be tolerated. We soon began to investigate the influences of various coatings on the chemical composition and the mechanical properties of the seam. They enabled us to approach the choice of coatings intelligently, to foresee the changes in the composition of the seam's metal and with the knowledge of the required seam to pick the precise components for the coatings.

The first blow was then struck at the "kitchen" which dominated in the choice of the coatings.

On the basis of this experience we no longer did any guess-work.

We tried now one now another flux composition, changed its components and their doses. It was arduous, exhausting and quite prosaic work; viewed from the side it would appear extremely tedious. It required a good deal of stamina and patience. But we gradually acquired faith that we would create the flux.

True, the seams, which we were able to weld towards the end of 1939, were still poor, but we no longer doubted we would finally get the quality we were after.

At all meetings Dyatlov persuaded us:

"It's only a question of time. We're not there yet, but we're on the right track."

He was right, but I was still afraid the experiments might take too long. Lack of knowledge often makes things appear simple and easy, but the deeper one delves into them the more complicated they become; then one's confidence and enthusiasm frequently give way to perplexity, which cannot but affect one's work. The danger was particularly great in our case since one of the group members was rather temperamental and his moods changed sharply.

I always considered a certain tempo very important in scientific work.

To set for oneself exact and definite time limits means to make one's thought work vigorously, assertively and purposefully, whereas a lack of certain, fixed dates in filling one's assignment frequently inclines to mental sluggishness and laziness. A rigid schedule is a whip that urges you on, keeps you going and prevents you from hunting for "valid reasons" in self-justification.

I could have simply set a date and back it up with an official order, which would have been the easiest thing to do. I decided to act differently. I prepared a draft letter, addressed by the institute to the Urals plant, in which I wrote:

"Dear Comrades, we took your severe criticism into account and now after a lot of hard work we promise to show you a new method of welding. The institute engages to devise a machine and demonstrate to the plant 30-metre-per-hour welding, i.e., three times as fast as heretofore. This welding regime will enable the plant to put out considerably more girders than it did when welding with an inclined electrode."

I read this letter to a meeting of the scientific workers of the institute and fixed a very rigid time limit:

"In the spring of 1940 we must have everything ready —the flux, the refitted machine and the welding regime."

"By June 1, we must invite representatives of the plant to the institute and show them the machine for welding with a flux-covered arc."

The hard schedule proposed by me perturbed some of my colleagues and caused differences of opinion and controversies, but my proposals were at last accepted unanimously.

I could have sent the letter to the Urals on my own, but I wanted the whole staff of the institute to feel the full responsibility. An inner conviction and faith always

mean much more than the formal signature indicating you know about the chief's order.

"Everybody pledged and, hence, everybody is responsible."

The Urals workers accepted our offer. They liked it and, besides, they ran no risk: we stipulated in the letter ourselves that the plant was to pay us according to the agreement a certain sum only if we keep all our promises.

Now the group working on flux-welding, as well as the whole institute, had a big incentive: the plant expected real results and we could not fail.

The words—June 1940—had become a battle-cry to the institute.

The work on the flux and the technology of high-speed welding was carried on with increasing vigour.

Not only the members of the special group, but all of us now had a single purpose. I tried to get as many people at the institute as possible to help the group since I no longer doubted that all of them would soon become enthusiasts and experts of automatic flux-welding. I knew from my own experience that any man, who had put at least a small part of his personal effort into something new in science, makes it part and parcel of himself and then passionately defends and promotes it.

Errors and mishaps did not particularly grieve me and if I saw any member of the group lose heart I invariably said to him:

"This should not frighten you. When you create something new errors are inevitable and you don't really have to worry."

"But it's a waste of time."

"Certainly, and it's a pity. But mistakes, too, are useful. They are also instructive, for they help to eliminate the wrong methods and, hence, bring you closer to your goal, to the only true solution."

We managed to keep our promise. By the end of May, 1940, we were ready to give account to the plant. The institute had built a welding machine with the necessary fixtures, elaborated the flux and the technology of welding.

We decided to call our new method "automatic high-speed flux-welding." We differed as to what we should call the flux. Some of us wanted to name it after certain of our colleagues, others—after the institute. I proposed that our first flux for automatic welding be called AH-1. The "AH" stood for "Academy of Sciences." I believed it essential to emphasize the role and services of the Academy which from the very outset, ten years previously, gave me support in the field of electric welding.

It might do well to tell the reader briefly of the essence and merits of the new welding method.

Like manual welding, automatic flux-welding uses the heat of the electric arc for melting the metal. The essential difference is that in high-speed welding the arc burns under a layer of melting flux inside a casing filled with gases and fumes and is therefore invisible. The flux fully isolates from the air both the arc and the melted metal. The welding head feeds the electrode wire and maintains the length of the arc.

As the seam is formed the arc moves along the welded place. Part of the flux is transformed into a slag crust, uniformly covers the seam and is easily removed after the seam has cooled. The seam represents an alloy of the electrode and the basic metals.

The above is a general outline of the process and probably does not tell the reader very much. We shall, therefore, cite concrete examples, give figures and facts to show what we thought the real advantages of automatic flux-welding were.

At that time an ordinary manual welder welded on the average 5 metres of seam per hour, whereas our automaton did 30. (In our days this figure has been greatly ex-

ceeded and we sometimes weld up to 150 metres per hour!) The "secret" lies in the use of currents up to 2,000 amperes, which is impossible in manual welding. In the automaton the current, fed to the electrode directly at the arc, makes it possible to use formerly unheard-of currents.

Flux protection possesses a remarkable quality: it concentrates the main mass of the heat, discharged by the welding arc, in a small area. In manual welding only one quarter of the heat is used effectively, while three-quarters are thrown to the winds. It is quite different with our machine. Nearly 95 per cent of the heat is spent on melting the metal, the electrode and the flux. The loss of heat is negligible.

The power of the arc is now concentrated; as a result the metal in the welding zone melts much deeper and can be welded to a greater thickness in one run. It stands to reason that the welding is much faster.

There is one more essential feature: since an uncoated wire is used in the automaton there is no need for expensive and complicated electrodes with special coatings.

The working conditions of a welder also change markedly. The arc burns invisibly in the automaton, gases are discharged in negligible quantities and the welder no longer has to protect his eyes from the blinding light or his hands from the dangerous sparks.

The machine performs all the principal operations. The welder does not have to hunch any more; he now works in a comfortable sitting or standing posture and tires much less than his colleague with the manual holder. It does not require months to train a worker, for he can learn to operate the machine in a few days. Several automata in a welding shop release a large number of trained workers.

The high quality of the seams also made us happy. The dry flux became a reliable protection of the melted

metal from the destructive penetration of oxygen and nitrogen. The seam came out compact, uniform and neat.

In a word, in automatic flux-welding I saw the embodiment of all the aims my colleagues and I had set ourselves at the time we had begun working on mechanizing welding. We had pursued these aims all through our searches, mistakes and mishaps. These aims had been: high productivity, good quality of seams and the freeing of welders from heavy manual work.

When I rejoiced at the realization of my cherished plans in 1940 I did not think we had reached the ideal. Nor could I have thought so, for I knew that automatic flux-welding would still have to travel a long and arduous way. But we were sure of the main thing—we had solved the problem in principle. Our first success inspired us and we were ready to undertake any work—however hard and painstaking—to make automatic high-speed welding the property of all of our industry.

7. BAPTISM OF FIRE

The representatives of the Urals Carriage-Building Plant were coming to Kiev, as was intended, in June. The institute had to show what it could do: it had to demonstrate automatic welding of a joint seam with the unprecedented speed of 30 metres per hour.

I saw that our people could hardly conceal their excitement in the expectation of the important meeting. But though excited they were not nervous.

Everybody realized it was not merely a matter of rendering an account to one of the plants, for it was much more than that. The new method was to be appraised by men of practice. A great deal, if not everything, depended on what they would say.

I often visited the welding laboratory in those days

and watched the work of the machine for hours at a time. I spent more time there than in my office. Then Dyatlov or Lapin would inform me of the results of the mechanical tests and the metallographic analysis of the seam. It was hard to find fault with them, the results were quite satisfactory. But only after they had been repeated dozens of times did I call a meeting for the first time voicing the thought that had occupied my mind all through the recent weeks:

"Suppose we invite some comrades from other major enterprises in addition to the Urals representatives? Perhaps we should also ask the representatives of scientific and economic organizations, who are interested in welding, to come? Arrange a sort of small conference. Let them all judge us at the same time. But if they like flux-welding we may acquire many followers. What do you say?"

I looked expectantly at my colleagues who were sitting in my office. They appeared a bit embarrassed. They were somewhat afraid, of course. What if we fail? Should they all witness our shame?

Something was gnawing at my heart, too, though everything seemed all right.

Dyatlov was the first to respond:

"I like the idea, you know. If we are afraid we better not show anything to the Urals people either. But if we are confident of ourselves, of the machine and of the results let's dare. After all we can't retreat."

"Why retreat?" Sevbo observed. "We hadn't started all this for just one plant. To my mind even if you write a hundred articles for all sorts of periodicals they won't take the place of one such conference. They may criticize some of our shortcomings? But that's just what we want."

Everyone in my office favoured a conference.

We started preparing for the conference and sent out invitations.

Delegates from all parts of the country, representing the plants and the scientific-research institutes of Moscow, Leningrad, the Urals and the Ukraine, came to Kiev. Some of the Union People's Commissariats also willingly sent their representatives.

The Urals workers were quite surprised at the meeting. They could hardly imagine what impetus they had given to welding by their recent severe criticism.

"We have come here to get a design of a machine, but found ourselves at a country-wide conference," they said.

At the institute we frankly distinguished the Urals people from the other guests and made no secret of the fact that it was they who had made us see our work from a different angle.

The day of the first open demonstration of automatic high-speed flux-welding went down in the history of the institute and is probably engraved in the memory of every one of its workers.

Both the exterior of the welding and the speed of the head astounded all the delegates. Their exclamations were heard in the laboratory:

"Thirty metres per hour! It's six to seven times as fast as a good manual welder!"

I saw that everything produced a strong impression. The arc was burning under the flux and its blinding rays were hidden. Instead of the welder bent over the manual holder, a shield on his face, there was a man walking around the machine now and then pushing the control buttons. And though he could not see what was doing under the melting flux, he was calm and composed.

And when two steel sheets nearly 1.5 cm. thick were at last welded in one run and the guests beheld a beautiful silvery seam, everyone around the machine involuntarily applauded.

Though I was very happy I remembered what awaited us on the morrow, for it was to be a day of the closest

and most painstaking scrutiny of the results of the analyses and of micro- and macro-ground ends, when puzzling questions might be asked, controversies might arise and claims might be raised. Well, it was all inevitable, necessary and natural, and we were not afraid.

Two important events occurred at the same time. The first consolidated our positions; the second opened for automatic welding a wide road to life.

The Urals people, like the whole conference, pronounced the results of the laboratory analyses quite satisfactory, while the speed of welding even exceeded their expectations. The plant accepted the design of the machine we had offered, and agreed to sign a contract immediately.

This time the institute won the old competition with manual welders.

"Now we can thank you from the bottom of our hearts," an engineer from the Urals plant said to me.

"And we shall always be thankful to you," I answered.

My words were not a mere return of courtesy, but an expression of deep conviction.

I had watched two members of the conference with particular care. They were representatives of an all-Union organization dealing with the manufacture of steel bridges.

Even at the time I had asked them to come to Kiev I pondered over a certain idea, but did not dare confide it to anyone.

I was afraid of being disappointed and for the time being kept it to myself. And when these two guests, whom I considered particularly important, their eyes glued on the electrode, watched it move along the joint of steel sheets, I, too, stared at them trying to divine the impression produced.

My doubts did not last very long: the two comrades were among the first to congratulate us and to speak enthusiastically of the advantages of the new method of

welding, which they now considered obvious and incontestable.

It was then that I set point-blank before them the idea that had troubled me for a long time:

"The construction of a big bridge over the Dnieper is soon to begin in Kiev. Nearly 120 kilometres of angular seams alone are to be welded. What is the sense in the manual, slow and not very dependable welding when the automaton, as you saw it yourselves, has proved its complete superiority? If you approve of this proposal the institute will undertake to design a machine, to work out the technology of welding for the bridge-building plant and to send its people there."

It was a very important moment in my life. What would the bridge-builders say?

Two of my life's most essential pursuits—bridges and electric welding—now merged into a single project, into one idea.

"That's just fine," one of them said. "We were going to talk to you about it ourselves. We like your proposal very much and we mean to come right down to business. We intended to weld with an inclined electrode, but we are sure your method is much more effective. You've converted us to your faith."

Several days later I had a contract, signed by the representative of the bridge-building organization, on my desk. All my proposals had been accepted.

My heart was filled with joy.

8. THE PARTY SUPPORTS AND TEACHES

Since the new method was so actively supported by the bridge-builders there should have been no doubts that the Kiev Navodnitsky Bridge would be the first bridge welded by high-speed automata.

Sevbo, usually reserved and composed, now hurried and urged his designers on. He himself never let the pencil or drawing rule out of his hands, and in three weeks the design bureau worked out the designs of a portal-type automatic welding machine and a rotary mechanism for turning the heavy truss members.

As early as July, only a month after the conference and the signing of the contract, the working designs were sent to a plant in Dniepropetrovsk. Soon afterwards one of our workers went there to set up and put the machine in operation.

It is very difficult, however, to do a good job on a structure if the latter is welded during assembly. It was therefore decided that all welding be done at the plant under constant observation of representatives of our institute. Here, with a roof over our heads, we could turn the truss members into convenient welding positions by means of the rotary mechanism and the machine would be well protected from cold, rain and snow. The members, welded at the plant, would then be sent to Kiev where they would be installed by means of riveting also under our supervision and technical control.

"Now it should be easy sailing... The plant is welding the truss members, the institute is attending to the quality of the seams and the assembly-men are assembling the bridge on the banks of the Dnieper."

That was the way some of our comrades pictured it to themselves. But, as it often happens, things worked out quite differently.

The administration of the Dniepropetrovsk plant (its representatives had not attended the conference) took the "Kiev fancy" with a grain of salt and did its best to delay the manufacture of the machine. It was probably afraid of the novelty of the method and the inevitable risk connected with it.

"Riveting may possibly have to give way to high-speed

electric welding, but why must we be the first to try all sorts of experiments?" the overcautious comrades from the administration reasoned. "The last word has not been said yet, the adherents of riveting in bridge-building will most likely try a come-back, and then you never can tell."

They were right, for such an attempt was actually made.

While they were procrastinating with the drawings of the welding machine at the plant, a violent controversy flared up in Kiev, Moscow, Leningrad, in the People's Commissariats and in the designing organizations.

At the institute we dreamt of building an all-welded bridge, a bridge without a single rivet. But it was only a dream, since we were not yet ready for it ourselves. I believed that building a riveted-and-welded bridge might be the first step in that direction.

On this, as yet restricted, field of battle we hoped to strike our first blow at our bridge-building opponents who were sticklers for the tried and tested riveting.

At the time there were quite a number of people who were afraid of high-speed automatic welding. In the worst case they agreed to manual welding; everything else was out of the question.

In October 1940, when I was invited to a conference at the Central Committee of the Ukrainian Communist Party, I realized I was in for a decisive battle.

I was hoping the question that agitated us—whether the Navodnitsky Bridge should be riveted or welded—would be finally settled.

In the spacious office of Khrushchov, Secretary of the Central Committee of the Ukrainian Communist Party, we met our adversaries. We greeted each other, inquired into the state of each other's health and affairs and peaceably took seats side by side. Outwardly there were no indications of an impending storm, but the calm was deceptive.

The very first words of the expert revealed the opponents of high-speed welding had acquired an active ally.

The venerable engineer was undoubtedly very much afraid. Above all he seemed to fear responsibility. He had firmly learned the golden rule that it was always easier and better for the peace of mind to say "no" than "yes."

All of the expert's reasons and arguments were aimed at calling the members of the conference to avoid rashness and at convincing them that the entire preceding practice of bridge-building was for riveting.

He kept his ace of trumps for the end of his speech, for the "curtain," so to speak.

With a spectacular gesture the expert took a foreign magazine with a bright, glossy cover and several markers out of his briefcase. In anticipation of the impression the expert asked us to see several photographs. The magazine went from hand to hand while the speaker commented on the photos.

"Look carefully, comrades. The photos show collapsed bridges which were built by welding."

I knew the magazine at first sight. It was the same issue the expert had at one time borrowed from me.

It was a clever move. The spectacle of collapsed bridges, even on photographs, can really create a strong impression on people who have no experience in welding.

I handed the magazine to Khrushchov and thought:

"The construction of welded bridges in Western Europe has brought them only trouble so far. Several countries have reported serious defects and even wrecks. We had recently learned of scandalous accidents when spans fell into the water. That was what the expert was now talking about, emphasizing the disasters with the welded bridges near Berlin and on the Albert Canal in Belgium. It was true. All the four bridges in Brussels collapsed in less than five years. Similar misfortunes had overtaken two railway bridges in Germany.

"These examples more than sufficed to discourage nervous people from welding bridges. It was clear that the

speaker banked on that for he was setting it all forth with an air of a discoverer, as if no one had ever heard or read of the wrecks in the West..."

"Is that all?" Khrushchov asked, when the expert, finally, stopped speaking. "You've painted quite a frightful picture. Now let's hear the other side. Perhaps it's not so hopeless after all. Please, Comrade Paton."

I realized how much depended on what I would say. All the demagogy of the expert aside, facts were facts: welded bridge-building in the West had thus far met with failure.

At the time my co-workers and I did not know all the reasons for the frequent wrecks. We were certain of one thing, however: it was not welding or its essential principles that had caused the wrecks, but its wrong and primitive employment. It was to this that I related my opening remarks.

"Firstly, the bridge-builders in Germany, Belgium and other countries," I said, "made an attempt to switch from riveting to welding, but left the design of the bridges essentially unaltered. Secondly, they had given no thought to the fact that Thomas steel, used for riveting, is not at all fit for welding and should be replaced by Martin steel.

"Last but not least, the welding was done manually, primitively, which, as is well known, cannot guarantee the high quality required in bridge-building."

Then I briefly stated the proposals of the institute.

"We must choose special steel, ensure high-quality welding and rigid work control. Above all the bridge must not be welded manually, but by high-speed flux automata.

"If all these conditions are observed, we will have no reason to fear the ominous forecasts of the estimable representative of the commission of experts. The devil is not so black as he is painted.

"Besides, we must call to order the inert and lazy people at the Dniepropetrovsk plant; they have been clinging to the old long enough."

I took my seat and excitedly waited for Khrushchov to speak. The problem was a subtle one even for specialists, no wonder we had so stubbornly debated it among ourselves.

Khrushchov stood up and pressed the magazine to the table with the palm of his hand.

"We will weld the bridge, dear comrades," firmly said the Secretary of the Central Committee. "Difficulties exist in order to be surmounted. We must teach our plant comrades sufficient respect for the new method. We shall be glad if the experts give us their support; there will be enough work for everybody. But if you try to frighten us, interfere with us, I'm afraid you'll have to step aside."

Silently Khrushchov handed the hapless magazine to the ill-starred expert, who took it mechanically, and blushed, completely at a loss.

Now, when the outcome of our stubborn struggle with the sceptics was becoming clear, I felt how hard the day had been for me. I was certain, though, the way was cleared and the rest was up to the institute. But the future bridge was only a beginning, we had to see beyond that. I went up to Khrushchov.

"You know of our new method of welding, Comrade Khrushchov, and you've just given it your support. I should like you to see it in practice. Come to the institute if you find the time, and we will show it to you."

"I'll gladly come and see everything," Khrushchov answered. "I'll be there in two or three days."

The moment Khrushchov arrived, he asked us to take him to the laboratory and show him the new welding automaton in operation. Several of my co-workers and I went together with him. Five minutes later the machine was on. The Secretary of the Central Committee intently

watched the head move along a piece of steel and feed the electrode at a set rate of speed.

I was making only the briefest and most necessary comments on the essence and peculiarities of the new method of welding. Khrushchov was quick to see its merits. When the black crust of the slag was knocked off, revealing the scaly surface of the welded joint, he turned to me:

"I saw it all, Comrade Paton. You and your comrades have done a big, I might say, a great thing. Automatic welding must find the most extensive application in our industry. We will try to utilize it immediately and on a country-wide scale. Will you, please, send a memorandum to the Central Committee right away. Kindly indicate the plants where you think we should start and what the government bodies must do for it. That's the first thing.

"Secondly: state what your institute needs. Don't stand on ceremony! It's worth it. We will report it to the Union Government."

I read my draft memorandum to the conference of the scientific workers of the institute.

Each proposal or amendment was carefully considered and discussed. But everybody felt somewhat uncertain as to the criteria to be used and the means we could count on.

No one knew the answers, and we were, therefore, very cautious and moderate. Reading the memorandum for the last time before signing it and sending it away I felt ill at ease wondering if we had not overdone it and asked for too much.

Several days later, after studying our memorandum, the Central Committee called us on the telephone. We were advised to extend the field of our research, to state the appropriations required for the construction of a new institute building and for the purchase of up-to-date

equipment for all the laboratories and shops. We were also told it might better serve our purpose to assign the production of flux to one special plant.

I had to rewrite the memorandum.

We ought to learn anew. We must use different criteria. We ourselves may not quite understand the import of what we had started at the institute, I thought at the time.

We really didn't. The Party helped us to appraise correctly both our discovery and its prospects.

9. TEST OF LIFE

We now had to prove, at all costs and as soon as possible, the vitality of high-speed flux-welding and to demonstrate that it was not a sickly laboratory creature, afraid of the severe tests of life and of a good factory draught.

The institute's brain-child successfully passed one of these tests at the carriage-building plant in Bezhitsa.

Dyatlov, Lapin and Gorlov, our scientific workers, and Shirin and Ulpe, our laboratory technicians, went to the plant. In two months' time they felt quite at home at the plant. Dressed in grimy overalls, they worked together with the plant's workers, assembled, put in operation, adjusted the welding machine, sharing the workers' chagrin when anything went wrong, and eliminated the defects, rejoicing when the seams came out good.

People from other shops came to see the new method of welding, watched the machine for a long time and then asked the administration to install similar automata in their shops.

From Dyatlov and Lapin's letters I gathered they were in no hurry to come back to Kiev, for they liked the work so much. They wrote:

"Here in the shops we have acquired a complete faith in the future of high-speed welding."

The new method took its second test at the Dniepropetrovsk plant. But from there we unexpectedly received alarming information. The worker, who had been sent there, reported that pores had been discovered in the welded seams.

"The opponents of welding are elated and are gloating over the fact that the institute has got itself in trouble with its 'welding,' " he wrote.

The new method had as yet to win recognition, and here it was being discredited at the very outset, in its very infancy. The worker's letters betrayed obvious perplexity:

"Everything seems to be in order—the technology is strictly observed, the machinery is adjusted, the flux calls for no alarm, but the damned pores do not disappear. They are threatening to discontinue welding. What's to be done?"

The last letter was followed by telegrams asking to "send instructions immediately."

I could not imagine worse luck. A "fine" memorandum and continuous defects in the first few dozen seams welded at the bridge-building plant. Shall I send someone to straighten things out on the spot? No, I should not trust anybody with it.

I took the very first train for Dniepropetrovsk.

I went to the shop directly from the railway station. Every operation of the machine, of its every part and unit, was thoroughly tested. Everything was really in order: the automaton worked flawlessly and produced . . . defects.

It was enough to drive one to distraction.

The machine was turned on again, and again those odious pores.

I looked out of the window in utter confusion; the sky was covered with dirty grey clouds, the rain was coming

down in torrents, it was damp and cold. I was sick at heart.

Suddenly it dawned on me:

"Where do you keep your metal?"

"Why, out in the yard, of course," the shop foreman shrugged his shoulders.

"How long has it been raining?"

"It's been pouring for about a week."

I flushed with anger:

"Take me to the yard immediately."

In a few minutes everything was clear to me: the parts of the future bridge were kept out in the open, their entire surface covered with a thick layer of red rust.

Streams of water came down on me and my companions.

"And you wonder where the pores and honey-combs come from?" I roared over the yard. "This is a real crime! Put everything under a roof and keep it there; get all that rust off the girders at the joints before you weld them."

This calling-down worked. All my orders were executed with precision, and the pores disappeared from the seams, as I expected, without leaving a trace.

As to our institute worker, I can say he had a few unpleasant moments. I told him rather harshly that he would come to no good if he pictured to himself the work at our institute as ministering in a sort of temple of pure science.

I must confess his panicky letters had upset me, too. What if we were too hasty about letting our discovery out of the laboratory? What if it turns out it can't stand on its own feet yet?

These doubts were now completely dispelled.

The construction of the Kiev welded bridge is a long and complicated story, which was fated to close only in

our time. I should like to finish this story because it is connected with a major victory of Soviet science and with much personal happiness in my life and work.

After my visit to the plant things there picked up noticeably.

But the war broke out and interrupted all of our peaceful, constructive work, including the building of the Kiev bridge. Several of its members, which they had managed to weld at the plant before June 1941, were utilized three years later in the reconstruction of another Dnieper bridge and are still doing their good work there. A design for a new railway bridge over the Dnieper (near Kremenchug) to replace the one destroyed by the Hitlerites was submitted to the Central Committee of the Party in 1946. In the Central Committee it was immediately noticed that, according to the design, the span-structure of this bridge was to be riveted. Temporarily postponing consideration of the design, the Secretary of the Central Committee asked me to study it and to submit a memorandum with my opinion of the possibility of welding the bridge.

I readily agreed, of course. In the memorandum I described all the advantages of welded bridge-building, as compared with riveted construction, and calculated the economy in metal and labour power, which welding would yield in the manufacture of the bridges to be reconstructed on our railways.

As a result, the Council of Ministers of the U.S.S.R. adopted a resolution the same year (1946) on the necessity of developing welded bridge-building in our transport. The resolution envisaged an extensive research programme, construction of experimental all-welded bridges, building of specialized bridge-manufacturing plants under the Ministry of Railways, etc. The Government demanded that the Ministry and other organiza-

Solemn opening of the Kiev Paton Highway Bridge, automatically flux-welded, 1953

tions seriously attack the problem of welded bridge-building.

Our proposal that the new Kiev bridge over the Dnieper be all welded was warmly supported. The bridge design, in which I actively participated, was considered and approved by the Government of the Soviet Ukraine in 1949.

Every builder of this large bridge bore a special responsibility: it was to be the biggest all-welded bridge. The institute was charged with the control of the quality of welding; it was also supposed to supervise the smelting, testing and deliveries of the steel for the bridge. And from the first seam, welded at the plant, to the last assembly joint on the banks of the Dnieper, the bridge was constructed with our most active and enthusiastic participation.

This time the Dniepropetrovsk plant coped brilliantly with the most difficult task it had been entrusted with. A special shop, excellently equipped for assembly and welding, was set up by the plant for the manufacture of the bridge members. The administration of the plant introduced the new technology in production and now swore by welded bridge-building.

A conference to discuss how the Government resolution was being carried out was called in Kiev in 1948. I must say it was being carried out very poorly. Small wonder that at this conference I had to fight another serious battle with the antagonists of welding bridges, who had not laid down their arms.

Like several years previously, demands were made for more and more research work. I replied that my persistence and irreconcilability in the matter of extensive automatic welding in the manufacture of welded bridges were based on a scientifically grounded faith in the enormous possibilities of this progressive method of welding; that I had always opposed and would oppose in the

future the modern imitators of Chekhov's "man in a shell," who in our days still repeat "what if something happens?"; that in my opinion we should build as many experimental welded bridges as possible rather than wait for "flying weather." Life itself would show who was right.

During the war and in the first post-war years automatic flux-welding definitely proved its vitality. Extensive practical experience was accumulated, a good deal of research work in the technology of welding and the strength of welded structures was carried out, special steel for welded bridges and new models of welding automata were created.

The new method and the machinery for vertical welding during the assembly of bridges, elaborated at the Institute of Electric Welding, enabled us to forge considerably ahead. We were able to reject welded bridges in which the assembly-units of the span-structures were joined by rivets and to turn, for the first time, to all-welded bridges with the welding done by automata.

In connection with this we faced the problem of altering the formerly planned design of the Kiev city bridge over the Dnieper and of working out a new design for it, as well as constructing a complex of structures which were connected with the bridge and were to improve the city plan on both banks of the river.

Before 1914 Kiev had been connected with the left bank of the Dnieper only by the Chain-Bridge. The Nikolayevsky Staircase, built back in 1854, joined this bridge with the centre of the city. This steep and inconvenient road runs through Pechersk, the most elevated part of Kiev. It was necessary to build better communications between the Dnieper and the city to satisfy the requirements of the growing automobile traffic.

The war interrupted the construction of this new road.

Now as I am writing these lines, a beautiful asphalted and wide, green thoroughfare runs from the Dnieper bridge and, by-passing the Kiev suburb, reaches the end of the wide Krasnoarmeiskaya Street, which is a direct continuation of the Kreshchatik. The new road has no steep ascents and, nearing the city, runs through formerly deserted lands, which have now been transformed into fine building plots. Trolleybus traffic has already been opened on this road.

A broad and convenient embankment with a tramway line connects the new bridge with Podol, the lower part of the city. Where the embankment crosses the thoroughfare an interesting approach to the bridge is being built, somewhat resembling a clover leaf in its configuration.

From the thoroughfare the bridge is reached by an overpass, built over the embankment.

The approaches to the bridge were so designed that the streams of automobiles moving in any direction do not cross. This makes it possible fully to utilize the traffic capacity of the bridge.

The "clover leaf" will be planted with verdure, including many varieties of decorative trees, bushes and picturesque flower-beds.

A park, bordering on the Dnieper, was laid out on the right bank to the left of the bridge.

A wide asphalted road begins near the bridge and runs into the distance on the left bank of the Dnieper. The highways to Chernigov, Poltava and Kharkov also begin here. The approaches to the bridge on this bank are planned on two levels: the thoroughfare, connecting the bridge with the highways, will run on top of a specially built overpass, while the automobile traffic along the embankment will move under the overpass.

The sands of the left bank, which is considerably less picturesque than the right bank, will also be planted with verdure.

A great deal of attention was also devoted to the architecture of the bridge. On the Kiev bank a ten-metre-high colonnade forms, as it were, a gateway at the approach to the bridge. At the approach to the bridge on the left bank there are two twenty-metre granite columns lighted from below by beautiful lanterns. Lines of graceful lamps and massive, artistically shaped, cast-iron hand-rails run on both sides of the entire length of the bridge.

In July, 1953, I stood on the bank of the Dnieper and admired the severe profile of the trusses of the largest all-welded bridge. My old dream had come true. I visualized the completed bridge and particularly deeply appreciated the sublime epoch which I lived to see.

Walking along the embankment now I saw how beautiful the capital of the Soviet Ukraine was becoming, how wonderful our life was getting to be.

My meditations were interrupted by one of our institute's scientific workers. He informed me that the automatic flux-welding of the 184th field joint of the trusses 3.6 metres high had just been completed and that the X-raying of the seams at the joint had again shown their high quality. This meant that in less than four months the new bridge would be open to traffic.[1]

I had devoted 35 years of my life to bridges. The last twenty-five years I had worked on electric welding. This all-welded bridge over the Dnieper embodied the sum-total of my long life of work: electric welding had met with bridge-building and this meeting had brought a new victory to Soviet science and Soviet engineering.

...I've run too far ahead and now I want to come back to what had happened after my trip to Dniepropetrovsk in 1940.

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[1] The new Kiev bridge over the Dnieper was solemnly opened on November 5, 1953. By decision of the Government the bridge was named after Paton, already dead at the time.—*Ed.*

On my way back I was in a particularly elated, holiday mood. Involuntarily I recalled every stage of the birth of flux-welding and mentally went back to the days when the institute suffered defeat in its competition with the Stakhanovites.

It had been a terrible shock, and that lesson should never be forgotten.

A conference of the scientific workers of the Ukrainian capital and the Stakhanovites from different enterprises was held in Kiev soon after my return from Dniepropetrovsk. Our institute also participated.

The story of how the Stakhanovite innovators outstripped the scientists and forced them to reorganize swiftly and decisively appeared very instructive to me. It was worth telling all my colleagues for their edification. I took the floor. My speech was recorded and I shall take the liberty of reproducing it here:

"At a similar meeting of scientific workers with the advanced workers and innovators of the Kiev enterprises about a year ago I spoke of the great achievements of the Stakhanovites in the field of electric welding. I pointed out that by boosting the welding current and using electrodes of greater diameter the Stakhanovites sharply raised the productivity of their work, that the Stakhanovites were 'dangerous competitors' of automatic welding and that the time was not far off when the Stakhanovites would outstrip it, though it was thought to be 2-2.5 times as productive as manual welding.

"My apprehensions were fully justified. Under the pressure of the Stakhanovites the Institute of Electric Welding had to seek a way out of the dilemma and find ways and means of raising the productivity of automatic welding. (Then I briefly told them what the reader already knows and began to sum up...) With metal 15 mm. thick the new high-speed welding proved 11 times as

productive as manual welding and 6 times as productive as the usual automatic welding with a coated electrode.

"Thus, the institute managed in a short time to considerably outstrip the Stakhanovites who were threatening its welding automata. But the role of the "vanquished" is in this case honourable and distinguished. It was they who impelled the institute to launch new research work in order to raise the productivity of the welding automata.

"Had there been no Stakhanovites we would still be content with the relatively low productivity of our automata.

"This experience in the life of the Institute of Electric Welding is a vivid example of how important the innovations of the advanced industrial workers are to us—men of science, how they propel our thought and bring us closer to life and its needs."

One of the "vanquished," a prominent Kiev welder, took the floor after me. He thanked our institute for giving the industry the first model of a high-speed welding automaton and promised the Stakhanovites would continue to spur us on.

A continuous ring of the long-distance telephone was heard in my office several days after the conference.

I was asked to come to Moscow.

To think how fast things happen. . . Decisive days were coming. What was awaiting me in Moscow?

10. MOSCOW DIARY

As soon as I came to Moscow I started a diary of my stay and work in the capital. I wrote my impressions down irregularly, from time to time, in my rare spare

moments. But even these notes reflected all that agitated and interested me in those effervescent and intense days of my life.

December 15, 1940

I can hardly believe I just came to Moscow this morning. The very first day has brought me such surprises.

Maybe Khrushchov has already managed to set my memorandum going? But won't the Government find what we propose a bit too bold?

Musing over all this I reposed in a deep arm-chair at a wide window of my hotel room.

Below an inexhaustible stream of automobiles rolled along the street. It stopped for several seconds at the traffic lights and then ran on again. The impatient automobile horns, the excited and cheerful rumble of the capital streets reached me on the fourth floor somewhat toned down.

In my elation I enjoyed the unceasing Moscow din.

"But how will it all work out?"

And as though in response to my thoughts the telephone rang on my table.

It was the same person calling who had called me in Kiev.

"Resting, Comrade Paton?"

I laughed:

"Can't help it."

"Rest in all conscientiousness," the representative of the Soviet of People's Commissars jested. "We've got a lot of work for you tomorrow. Please, come and see the draft resolution of the Government and the Central Committee of the Party on introducing high-speed flux-welding in our industry."

Resolution of the Government and the Central Committee? And the draft ready on my arrival?

Naturally, I lost my peace of mind.

"That's just wonderful. But why put it off till tomorrow? I'm coming right over. It's just across the street. No, no, I can rest during the night and, besides, I had enough sleep in the train. I'm coming right over."

Within an hour I was back in my room absorbed in papers.

I felt as though I were rereading my memorandum. All the institute had proposed was included in the Government document. But what scope our proposals had acquired! The range of application was immeasurably extended, while the time limits were considerably reduced. The document made the People's Commissars personally responsible for observing every paragraph. The Government generously granted everything the plants might need to utilize automatic welding and set up a special bonus fund of 1,200,000 rubles for industrial workers who might distinguish themselves in the new method.

I reread one of the last paragraphs several times. More than 3 million rubles were appropriated for the construction and equipment of a new institute building and 100,000 rubles for especially distinguished scientific workers. 50,000 rubles was granted me personally.

We, certainly, never expected such high appraisal of our modest work. But the most important thing was that we were being offered the widest opportunities for work. Nearly 3.5 million... But recently, when we were just beginning, I was happy about 200,000 rubles.

To think that I had been asked to wait till tomorrow!

I began to write my remarks and suggestions right on the margins of the draft:

Set still shorter time limits for the suppliers of welding heads, flux, electrodes and motors; fix their production programme quarterly rather than annually.

Replace certain plants by others.

Double the assignment for the manufacture of flux.

Charge the People's Commissariats with submitting

their plans for introducing welding for 1941 as well as 1942...

In jotting down these remarks I fell to thinking involuntarily.

It was only six months since high-speed flux-welding had emerged from its "laboratory diapers" and now it was being given every opportunity to spread in industry. The efforts of a group of scientists were augmented by those of a dozen People's Commissariats and numerous plants, while in the Kremlin, but a few steps away, the leaders of the people were pondering over the same problem.

Immediately another thought flashed through my mind: I wish I were born twenty or thirty years later. Whatever you say, I'm past seventy. What a joy it is to live and work in our remarkable time. I'm sorry my youth and early adulthood were spent in the stuffy atmosphere of tsarist Russia. But for all that I'm young again.

December 21, 1940

Now it's not the draft before me, but the resolution itself. The resolution termed automatic flux-welding the most progressive type of welding. Isn't that the highest recognition accorded to our modest work?

Not so long ago we groped in the dark, pulverized bottle glass, strove to guess the secret of the arc process taking place under a layer of dry flux. But as soon as we got on the right track, we found that all of our industry needed our method and adopted it the moment we had something to show for it.

High-speed automatic flux-welding will cease to be a subject for discussion. The Government document had it in black and white:

"The Soviet of People's Commissars of the U.S.S.R. and the Central Committee of the Communist Party of

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the Soviet Union (Bolsheviks) note the considerable superiority of the method of automatic electric welding with an uncoated electrode under a layer of flux over the other methods of arc welding."

The document also mentioned the fine work done by the institute in elaborating the machinery and technology of high-speed automatic welding.

Day before yesterday I was asked to come to the Kremlin. All the People's Commissars, mentioned in the draft resolution, gathered in the office of the Vice-President of the Council of People's Commissars. Khrushchov was also there.

The people, whom the entire country knew, intently listened to me, delved into the details, asked questions in order to make clear what the new method of welding could yield to industry.

It was the first time I had seen so closely the leaders of our industry.

Listening attentively to the remarks of the People's Commissars I thought of the great responsibility of the men of science. Any mistake we make, however small, if neglected, is likely to harm our industry, because it is inevitably multiplied by failures in dozens of plants.

I remembered how at one time, at the end of last century, I importuned the tsarist ministry of transport and fretted because I was unable to find application for my knowledge. Today, together with members of the Soviet Government, I am editing a state document word for word, a document, which offers every opportunity to our discovery.

I saw Khrushchov the following day. "Here we are taking the first decisive step to supplant the unproductive and hard work of manual welders by a mechanized industrial method. Great thing, eh?" he said. "The Party and the Government are undertaking, together with you, Comrade Paton, to oust the primitive methods and back-

wardness from welding. It goes without saying that the high-speed method has a great future. Incidentally, what do you think of our resolution?"

"It's an historical resolution for welding and the science of welding," I answered promptly. "It defines very clearly what is to be done, when it is to be done and who is to do it."

"Quite right," Khrushchov remarked heartily, "but to adopt a good resolution isn't all. The resolution is only the beginning and not the end. Even the most authoritative document must be backed by a man or by people who are vitally interested in carrying it out."

Khrushchov smiled looking me straight in the eye:

"But where can we get such a man in Moscow?"

Much to my regret I was unable to suggest anything, since the new method had been developed at our institute.

"Then let me tell you the Government wants you to come to Moscow for six months or a year to supervise the carrying out of our resolution. We may run into the sluggishness, red tape or even direct resistance of the conservatives. We need a man who is enamoured of his idea and is capable of giving battle to its antagonists. You know the old, the dead won't leave the stage of its own accord."

He was silent for a while.

"Well, what do you say?"

"Neither the institute nor I will spare any efforts to justify the hopes of the Government," I answered.

He regarded me closely:

"I'm very glad you agree. But only a fervent desire to work is not enough. We must vest you with authority. You will be appointed member of the Machine-Building Council under the Council of People's Commissars. Malishev is the chairman of this Council. In case of any difficulties or hindrances call on him or on me. Write, don't be shy, it's no trouble to us."

"I'm very fortunate to have such opportunities for my work. But I can't leave the institute for a whole year. Please, allow me to spend a week in Kiev every month."

"But won't these trips to and fro be too tiring?" asked Khrushchov.

"They won't. Besides, I must do it in the interests of the work."

I'm going home the day after tomorrow. I've got the consent of the Government to combine my work in Moscow with the work at the institute. I'm taking along with me the resolution of the Council of People's Commissars and the Central Committee of the Party—the most precious prize for all my co-workers.

January 15, 1941

I'm in Moscow again; I've been here for two weeks and will have to stay here a long time. I feel somewhat out of place and uncomfortable in a big office of the Council of People's Commissars, and the first thing I did was to replace the cumbrous "ministerial" inkstand on my desk with an ordinary class-room inkwell.

I work thirteen to fourteen hours a day, since now everything depends on our energy and persistence.

Our institute and the Central Scientific-Research Institute of the Technology of Machine-Building have been charged with supplying twenty of the country's largest plants with working drawings of automatic welding machines and with rendering them technical assistance in setting these machines up and putting them in operation. Dozens of absolutely different machines, and within only six months they must be set up and running—welding carriages, cisterns, boilers and trucks.

But these twenty plants will be able to start their machines running only when they get the welding heads, the control panels, powerful transformers, the flux and

silicium-manganese wire. I have been made personally responsible for the manufacture of all this extensive and complicated equipment.

All requisite orders have already been placed through the corresponding People's Commissariats, and we are now supplying the plants with machinery, instruments and materials. 200 welding heads, to be manufactured after our drawings, have been ordered at the Avtomat plant in Kiev. I helped the plant to get the funds for the necessary materials and motors and organized the tests of the heads at the plant.

The Kiev Transsignal plant is to produce dozens of control panels and apparatus cases according to our drawings. This plant has a hard job: it will have to adapt itself to the scheme of each individual welding machine as it is elaborated at the institute. The other orders have been placed with the Leningrad, Kharkov and the Donets Basin plants.

I must constantly keep an eye on the whole business to see that no one is behindhand, for the miscarrying of a single order threatens to frustrate the entire resolution.

March 20, 1941

I have been awarded the Government Prize First Class for the "Elaboration of the Method and the Machinery of High-Speed Automatic Welding." This was reported in the newspapers. The news is as happy as it is unexpected. As far as I know the Ukrainian Academy of Sciences never nominated me for the prize...

The day before yesterday the *Pravda* printed my special article "High-Speed Welding," in which I described the history of the birth of our method, its advantages, how it was paving its way in industry and of its pioneers at the leading plants I hope the article may cause new people to take an interest in high-speed welding. The

welders of the capital are all for it. Since my recent report at their conference they have taken many concrete measures.

The country-wide conference of engineers and scientists working in the field of welding has responded with equal enthusiasm. Now, after the flattering and pleasant words, we shall expect them to join in our struggle for the new method.

On our proposal all the plants, enumerated in the resolution, appointed their representatives who maintain permanent contact with us. We try to see ahead and think of the future masters of the machines. Plant superintendents of high-speed automatic welding are taking courses at the institute in Kiev. I've met them all personally.

Equipment, received from all parts of the country, is being installed at the plants. The director of the Avtomat plant recently brought samples of heads and received a substantial bonus. But in addition to the encouragement he was given a schedule stipulating that the plant was to manufacture 200 heads every ten days.

They are rather afraid of us at the plants now because we won't stand for any poor quality in the welding equipment. We make sure the plants observe their time limits, since every plant has its own plan and our order is an "additional load." They groan, but, all in all, discharge their tasks conscientiously.

In the beginning I pondered over the following question: must all this be the concern of a scientist and must he wage war on those who take only a parochial view of everything? Or, perhaps, we must only give our discoveries to the people and undertake other research work? Isn't this our direct calling? Now, after several months' work in Moscow, the very idea strikes me as preposterous. Is there anything more absurd in our Soviet environment than the figure of a priest of "pure science"?

The People's Commissariat of Ferrous Metallurgy, for example, procrastinated for a long time and wouldn't reduce the diameter and weight of the electrode wire coils manufactured for the welding automata, thus holding up the order. It seems, big, heavy coils were "more profitable" to it. Some official was too lazy to bother with such "trifles," and the whole business of spreading flux-welding in industry might have failed for his neglect.

The organization in charge of glass production engaged in endless discussions on the manufacture of welding-flux, but never yielded a single kilogramme of it.

What is the use then in all our discoveries and the finest laboratory machinery if the plants get no wire or flux? Can a scientist wash his hands in such cases if his science really means something to him? And what must I do?

I sent a memorandum to Malishev in biting and angry terms though it concerned persons in very high standing.

Malishev ordered forthwith a general check-up on the carrying out of the whole resolution. Our report on the results of the check-up was immediately discussed at the meeting of the Machine-Building Council and all, who had anything on their conscience, felt quite uncomfortable that day.

True, one of the members of the Board of the People's Commissariat of Ferrous Metallurgy tried to exonerate his subordinate, who was responsible for the retardation in the manufacture of the silicium-manganese wire.

"Some inventors think up new standards, but it is we who have to bear the responsibility," this orator stated haughtily.

Unable to contain myself I jumped up:

"So that's how you feel about it? The Government appreciates high-speed welding, while for you it is a burden, 'a sort of invention'?! Will you ever put an end to it?"

Malishev spoke after me. Briefly, but quite persuasively he made it clear the Government would not stand for

such inefficiency in the carrying out of its directives. The representative of the glass industry was similarly reprimanded.

The results of the Government's rigorous interference ensued with amazing swiftness. The Dzerzhinsky plant in Dnieprodzerzhinsk and the Beloretsk plant in the Urals were given immediate orders for the manufacture of 2,000 tons of electrode wire, while the Proletary glass factory in Lisichansk vigorously set to producing the flux.

March 30, 1941

We are trying to solve all our problems as a whole rather than to do well at some particular sectors.

While using special silicium-manganese wire, we have been doing research work in welding with ordinary low-carbon wire at the Institute of Technology and Machine-Building in Moscow, at our Kiev Institute and at the Electric plant in Leningrad. Our joint efforts proved successful. New and improved types of flux to be used with accessible low-carbon wire came into being as a result of similar friendly competition.

Rigid time limits, concrete assignments, the necessity to design for definite plants rather than "in general" determined the nature of the scientific work at the Institute.

In 1941 we developed a new, model A-66, welding head. In comparison with the former models it had incontestable advantages, primarily, greater reliability in work. We increased the speed of electrode-wire feed, ensured the feed of high currents, fixed a dependable copying device for directing the electrode along the seam covered with a layer of flux.

Such a suspended welding head requires the construction of a machine for moving it along the welded article. This machine is usually cumbersome and quite intricate in manufacture and operation.

We have been pondering over the problem of eliminating this inconvenience for the last two years, since this impeded the development of automatic welding. We have been particularly urged on by the ship-builders. They needed a compact, convenient and light apparatus which could propel itself along the seam without the aid of a special machine. The institute produced such a self-propelled automaton in 1939; we named it—the welding tractor. (This name was suggested by its outward appearance and the fact that our automaton moved along the steel sheets like an agricultural tractor along a field.)

But this tractor, naturally, found little application as long as the machines prevailed. Our designers spent all their time on designing these machines. They were machines for welding girders with straight seams, for welding longitudinal and circular seams of boilers and pipes, and vertical lathes for welding round seams on horizontal and inclined planes; there were also universal machines for all types of seams.

Our institute had never yet lived so fully; our workers had never yet experienced such satisfaction. To be sure, our very first experiences in putting our laboratory achievements in practice clearly showed us that the more we advance, the greater difficulties we encounter. But then these were not difficulties of stagnation, but of a precipitate movement towards a great goal.

Quite recently we thought ourselves victors for having compounded our own domestic flux. But the Proletary plant produced the first big batch of 200 tons of flux and put us out of countenance. The flux founded in the plant's flame furnace proved worthless. (All the experimental welding at the institute had been done under flux smelted in an electric furnace.) It was a new undertaking for the plant, but we specialists were also unable to explain the reasons for the failure; we could not think what was wrong.

The comrades at the institute were lost in conjectures, took their inability to find the reasons very much to heart, and bombarded me with anxious letters and telephone calls. I insisted the experiments be continued, made some suggestions, but was no less alarmed than my co-workers. It was no trifling matter: no flux—no high-speed welding.

Time would not wait. The Proletary plant put the matter to us point-blank:

"Either you do something about it or we blow the furnace out."

One of our scientific workers went to Lisichansk. Some of the plant workers were at the institute. They reported the results of their experiments to each other and to me by telephone.

Our persistence finally brought us success. The conjecture that the flux smelted in the plant's furnace was insufficiently deoxidized proved right. We proposed several changes in the technology of production, the plant accepted them and the flux immediately improved.

The bags with the long-awaited flux could now be sent to dozens of plants which were waiting for the results of our experiments.

Our motto—"don't consider your scientific work complete until tested in life, in practice"—proved right once again.

May 25, 1941

Now I can own up to it: the time limits, set in the resolution, at times appeared too short even to me.

It turned out, however, that life in our country ran ahead of the boldest plans. It is only May now, but many of the plants have already installed and put their machines in operation.

Of late I have been living "on wheels"; I can't stay put. I visited some of the country's largest plants in Ka-

linin, Bryansk, Podolsk, Gorky and Leningrad. Wherever I went I made sure to lecture to the engineers, demonstrate our film on high-speed welding (the round box with the film follows me wherever I go) and conduct a conference with the high-speed welders invariably in the office of the director and with his personal participation.

I get thoroughly tired, but then I see with my own eyes how our heads flux-weld enormous boilers, railway carriages and large girders.

The main reason for my trips to the plants is to see how the resolution of the Council of People's Commissars and the Central Committee on introducing high-speed automatic welding is carried out at the plants.

My general impression of all the trips is that the industrial people are satisfied with the machinery, the unprecedented speeds and the good quality of the seams. Flux-welding is its own best advertisement.

But it's not only an exchange of pleasantries with the workers. High-speed welding is only making its first independent steps, and I cannot always use the most polite terms to instil the necessary respect for it.

Some people think that as long as they have an automaton they can do as they please with it. At the Krasnoye Sormovo Plant, for example, I saw something that aroused my indignation. The sky was clouded, it was drizzling, but the workers were welding outdoors. What sort of welding could that possibly be?

I gave them a real calling down; I shouted at them:

"You'd never think of running your lathes or other machines outdoors, would you? But you believe you can do anything you like with the automatic welding machine?!"

Wet flux fully guarantees the formation of pores in the seams. I must have looked furious because the welding machines were immediately put under a roof.

At many plants I see our institute instructors who introduce automatic welding.

Now I see what a happy idea it was to organize a staff of these instructors. I don't believe the other institutes have them. But then only a short time ago there was no automatic flux-welding either.

At the time high-speed welding emerged from the institute into the big, wide world I wondered who would promote it and introduce it in the plants; some of the workers at our institute did not think it was our business.

I differed with them, but did not know myself what to do. We had but few scientific workers and I could not see any sense in diverting them from their main work for any length of time.

I began to select engineers for the institute, principally, from my recent students. To be frank, I tried to avoid specialists in manual welding for fear their old experience might act as a deterrent. I preferred men who had just come out of college so that we could teach them high-speed welding at our institute.

We were trying to find the best forms of work to aid us in introducing high-speed welding in industry.

At first we planned to send to every plant a group consisting of a technologist, a designer and an electrician, but our activities were increasingly extending, we had to set up our machines in 20 plants and did not have enough personnel. We had to send only one person as an instructor to each plant. I wouldn't let a single one of them go to a plant without first "questioning him with prejudice." I put puzzling questions to them intentionally, for they might run into these questions in the shops where they would be looked upon as "gods" and where they could not afford to be embarrassed.

But then I never did leave the instructors in peace. Now I make them write to me in Moscow every few days, immediately signal any mishaps or surprises and boldly complain about the big chiefs with whom we could deal easier here in Moscow.

Sometimes I wonder how widely the walls of our institute have "expanded." We pave the way for the plants while they back us up and correct us with their experience. This makes us all move ahead faster.

I am convinced only these common efforts will help us make real accomplishments in science and engineering.

The complaints of certain scientists therefore sound very strange to me when they often accuse the men of practice for presumably failing to appreciate their technical ideas. A good idea alone is not enough. We know many cases where important discoveries had been shelved for years because of the passivity of the scientist and his inability to fight for the introduction of his invention in life.

What's the use of making a discovery and then burying it in the laboratory without seeing it through? First translate your discovery into the language of engineering, into the language of production, bring it to the plants, put it on its feet, smash the resistance of those who are clinging to the old, and then boast of your victories.

I think I'm right after all, though such ideas do not appeal to everybody.

June 5, 1941

Recently I learned two very useful lessons.

Not so long ago I wrote that life had dispelled our fears concerning the time limits. Now I know that the introduction of flux-welding by twenty plants in the first six months is a rather modest task under our Soviet conditions.

In addition to the plants, enumerated in the resolution, many other enterprises applied to us for welding equipment. They had heard of the new method and without any compulsion decided to make use of it, unafraid

of the trouble it might cause them. And we readily give them sets of our reserve welding machinery.

We considered ourselves real dare-devils when we called the figure "20," but reality had run ahead of us. It is a good lesson life has given us. A lesson from below, so to speak.

And here is a lesson from above which has also taught me a great deal.

One day I was visited by Moskatov, Head of the Chief Administration of Labour Reserves.

I could not guess the reason for his visit offhand, because Moskatov had nothing to do with the higher educational establishments in which we intended to train high-speed welding engineers.

"Tell me," he began from afar, "is it right what I've heard? Are you trying to get the welding departments of five industrial institutes to begin the immediate training of specialists for you?"

I nodded.

"You intend to get your technicians and foremen from the specialized welding schools?"

"Quite right."

"Fine. But where will you get the welders and adjusters?"

I thought that a very simple question.

"The plants will train them. Besides, how many of them will we need to start with?"

Moskatov smiled:

"Hm... The Government sees further than you and I. We don't really need very many of them today. But how about tomorrow or the day after? We will soon have thousands of high-speed welding machines in operation. Have we looked into the future, Comrade Paton? The Government has charged us to start training adjusting instructors in June. And not helter-skelter, but in twelve schools at once. Now what do you say?"

What could I say? This opened such horizons before me that all our big present work appeared to me as only the first modest approach to something enormous. Thousands of machines meant thousands of welders. To think that only a year ago three or four men in the whole country—my closest assistants—nervous and agitated, were just beginning to flux-weld two pieces of a steel girder.

June 19, 1941

My textbook on high-speed welding has come out of print.

I wrote it in the mornings, getting up at day-break, and on my days off, taking my manuscript with me to the country-house, selected at one time on the bank of the Moskva River by Maxim Gorky. There, in peace and seclusion, I worked at my ease and wrote rather fast. I usually went there on Saturday evening and stayed over Sunday.

As soon as I finished the book, the Government ordered it to be published in an unheard-of short time—six days. The demand for the book is so great it already requires a new edition. I have a feeling it needs many essential corrections. Life unceremoniously rejects and forces us to review what only yesterday appeared stable and unshakable.

I visited Kiev recently to check up on the preparations for the construction of the new institute building. I had to change a few things in the plans and the designs. We must build the laboratories today which we shall only need tomorrow and get the equipment for the solution of scientific themes which we can only see in vague outline today, but which will soon come up for our serious consideration.

It is not enough for real science only to march in step with life; science must run ahead of the present needs

of the national economy or else it will soon lag behind and degenerate.

I've been in Moscow for six months, perhaps the fullest and most strenuous months in my long life.

But what have we done in these short fleeting months?

I shall answer briefly: the resolution of the Party and the Government on introducing high-speed welding has been fully carried out by all plants with the exception of two, which means our institute has done good work.

On our proposal the People's Commissariats had drawn up plans for introducing high-speed automatic welding during the second half-year. We transformed them into a country-wide plan with considerable increases.

We are particularly interested in the Urals plants. It took me a long time to decide whom I should send there and finally I made up my mind to go there myself. It is certainly a long and tiresome trip, but then I shall see the Urals with its powerful industry and the changes wrought by the five-year plans. I only know the Urals from Mamin-Sibiryak's novels and my ideas are probably hopelessly outdated.

Day after tomorrow, on June 21, I shall start on my way.

Part Four

CRUCIAL TEST

1. BUSINESS TRIP TO THE URALS

IN THE EVENING OF June 21, 1941, I left Moscow for the Urals.

No sooner was the capital's terminal left behind than the familiar outlines of the overpass, I had designed more than forty years ago, flashed past the windows. It was my first independent work after graduation from the Petersburg Institute of Railways. Nearly half a century had elapsed, and what half a century it was!

The Tagil Express sped eastward. Gusts of wind burst into the open windows and flapped the silk curtains.

Ahead of me are thousands of kilometres of railway and a few free days without business conferences, visits to the People's Commissariats and plants, without telephone calls, answering of letters, proof-reading and scientific reports, without the strict time-table in which every ten minutes had to be accounted for.

Taking the train, I looked forward to a fine rest, but in the morning I already felt tired of my forced idleness and yearned for my customary work. In the train we lived the usual life of all long-distance trains: some passengers played chess, others devoted their time to reading.

Acquaintances were struck up easily and swiftly. The natives of the Urals were naturally in the centre of attention. According to them there wasn't a finer, richer or more generous land in the world than their Urals.

It is hard to fight one's own nature and putting my spectacles on I spread before me the 1941 thematic plan of the institute. I wanted to think it over once more at my leisure.

I looked through the plan twice, but was unable to concentrate. It would seem that being alone in a comfortable compartment one should be able to. But that was not the case.

Heavily loaded goods trains rolled in a never-ending stream from the opposite direction, tank-cars black with dust and crude oil rumbled over the rail-joints, and passenger trains flashed by.

There was something exciting and thrilling in this counter rush of trains. All that was taking place before my eyes bespoke the great and intensive labour of our people and suggested every opportunity for creative research work.

It took but a few moments for a passenger train to get out of sight, but my experienced eye was able to notice an abundance of rivets in the sides of the carriages. I thought it was absurd to spend so much time, labour and metal on riveting when we've definitely proved it was possible to build twenty-five-metre-long all-welded carriages. I recalled my talks with engineer Travin, the initiator and untiring propagandist of welding. Our institute was elaborating experimental equipment for welding all-welded carriages.

I make a note in the corresponding section of the plan: to expedite.

Endless tank-cars again. At one of the stations I wanted to go up to a train of tank-cars, wipe the dirt off the joints of the steel sheets and see if the tank-cars were

riveted or welded. But I knew that in a hundred tank-cars I would find only one or two welded ones anyway.

Out of my briefcase I take the report on the introduction of welding in the manufacture of tank-cars; I have taken it along for a final check-up.

I find very little comfort in the report today. Something has been done, but it's only a beginning. I'll have to do better when I get back to Moscow.

I'm no longer bored. Even while I'm travelling in a railway carriage life continues to teach, correct, guide and counsel me. It makes me feel good to know that what we are doing today, what we intend to do tomorrow and have reflected in our plan is not unrelated to life, but marches right along with life.

I was diverted from my thoughts by a remark of my compartment neighbour:

"Why is the radio silent all morning? It played and sang all last night, and now we can't get a sound out of it. Wonder if it's out of order?"

He had hardly spoken these words when we heard the strained and excited voice of the Moscow announcer:

"We are broadcasting Comrade Molotov's speech..."

I felt as if the bottom had dropped out from under me. No doubt something very important happened, something extraordinary.

"Can it possibly mean war?"

It was hard to believe.

But it was war. On that never-to-be-forgotten Sunday, on June 22, 1941, in the Moscow-Nizhny Tagil train, I listened together with all Soviet people to Molotov's speech. Perfidiously, without declaring war, fascist Germany attacked our Motherland. The Hitler hordes invaded the Soviet Land. Among other cities the Germans raided Kiev. They want to raze to the ground peaceful towns situated far from the front. I could judge by this alone

what barbarians we would have to fight. This will surely be no trifling war.

I'm listening attentively to every word and even to the way every word is intoned. My mind works feverishly:

"What am I to do? Where do I belong? I'm 71 years old, but the war directly concerns me, too."

My first decision:

"I must immediately go back to Kiev, to the institute, to my family. Maybe the institute and the house, in which we live, have already been reduced to ruins; maybe under the ruins... No, I must not hesitate, I must go back."

I scrutinize the frowning, concentrated faces of my Moscovite neighbours. They are, apparently, trying to decide the same problem: should they go home or continue on their way?

It's a long way to Tagil yet. I can get off my train at the first big station and take a return train.

But how about the Urals plants? The war has not cancelled my assignment. This is no private trip, I'm on government business.

An inner voice suggests:

"You are responsible for the only Institute of Electric Welding in the country, your family is in mortal danger."

The conductor announces the approach of our train to a major railway junction.

I look at my neighbours. No one is packing. They have all made their decision silently and unanimously. It is also my decision.

I mailed two letters from this station. The first to Kiev, the second to the Government:

"At my age I could hardly be of any use at the front, but I have knowledge and experience, and I beg you to use me as a specialist wherever you find it possible and necessary. Our Motherland is in danger, and I want to devote myself wholly to its defence."

Having mailed this letter, I felt relieved. I felt as if I had joined, at least mentally, the army in the field.

I unfolded the 1941 thematic plan of the institute again. It was a different year now: a year of war. How long will it last? Months? Years? It made no difference, we had to win it.

I now read paragraph after paragraph with "war" eyes. Much of what appeared as the most important and urgent only this morning now receded into the background. The all-metal carriages will wait, today it is more important to speed up the production of arms. The long-range research themes, which will yield tangible results only in 2-3 years, must also be postponed.

We must work on problems the solution of which is necessary to the war, to victory. But what problems? Life will show. I was not clear on them as yet. The war will be a severe test for all of our science, which also means us and our institute.

The train radio was, for some reason, silent again. At one of the stations I got out of the carriage to hear the latest news. Somewhere, in the deep recesses of my soul, I still harboured a hope:

"Maybe it isn't as serious as all that? Maybe the Germans have already been beaten back?"

But the news from the front was hard. The enemy was meeting stubborn, heroic resistance everywhere, but was driving on just the same. The brutal bombings of cities, including Kiev, continued.

Men were marching past. The front was thousands of kilometres away, but here, too, the war at once put a stamp of severity and anxiety on their faces. Each man was thinking of his place in the ranks. The same thoughts occupied my mind. We, electric welders, are men of an especially peaceful occupation. Well, we'll have to relearn. Welded seams can firmly join not only the sides of carriages, but also the armour plates of tanks.

The train arrived in Nizhny Tagil on a cold, grey morning. The cold and severe mountain and forest landscapes of the Urals, so unusual for a southerner, by contrast brought to my mind the bright, sunny colours of the blessed Ukraine. Her fields were now treaded not only by combines, but by tanks as well; blood was flowing in her western areas, the sky was red with the glow of fires and a battle to the death was being fought. And here, before me, spread the mighty Urals, this gigantic smithy of the country. No fascist ace will ever be able to fly here.

I spent two days at the first plant I visited in the Urals. Everything was in order there. It was the plant for which we had designed our first automatic welding machine. Oleinik, one of our instructors, set it up, put it in operation, and the machine had welded girders for railway trucks ever since. I was greatly impressed by the plant. It was a large and very rich enterprise with steel and cast-iron smelting shops, with a forge and press department, a department for moulding carriage wheels, a gas plant and a large central laboratory. The people here appreciated high-speed electric welding and I left the plant reassured.

I went to another plant. As far as I could remember bridge structures had always been assembled out in the open. Here everything was done indoors, in splendid, large shops. This plant was a real child of the five-year plans. Frolov, the chief engineer of the plant, showed me the machine for flux-welding big I-beams. I had met him in Moscow at the time we were beginning to design this machine. Frolov was now proudly demonstrating the machine in operation.

At the plant I was told I was wanted by Malishev, the Vice-Chairman of the Council of People's Commissars.

"Malishev?" I was surprised. "But we've only parted a few days ago in Moscow."

"He flew here on the very first day of the war. He is very eager to see you."

Malishev had already left the plant, so I had to follow him to the station. I found him in his carriage and he told me he was making the round of the Urals plants which were to switch to war production. He had already visited one of them where they were to launch large-scale rolling of thin aluminium sheets.

I was amazed that, literally several days after the war had broken out, the Government was taking such vigorous measures to create a "second line of defence" in industry for any eventuality.

Briefly, but eloquently, Malishev told me of the part the Urals was to play in supplying the Red Army with arms and ammunition. I understood that the Party and the Government had deeply thought-out, clear and extensive plans for expanding the defence industry.

Malishev emphasized the war was to be a serious and, probably, a long one.

"Here, in the Urals, it is cold and nature is rigorous," he said, "but it will soon be hot with great and intensive human labour."

I felt those words were meant for me, too. They seemed to say that here, in the Urals, where a powerful industry had been created in recent years, the workers of our institute could find extensive and useful application for their knowledge and experience.

Bidding me farewell Malishev said:

"You might take my plane back to Moscow and thence to Kiev if you wish."

"It is very tempting," I answered, "and I'm very much obliged, but I have to visit the Urals Heavy Machine-Building Plant in Sverdlovsk."

This plant impressed me even more than the other two. I could not help admiring this "plant of plants." The plant was producing unique metallurgical and machine-

building equipment. It was not putting out machinery in series, but in individual gigantic aggregates, which was responsible for certain difficulties in the use of high-speed welding. What was the sense in building relatively expensive welding machinery for the manufacture of one or two unique machines? Back in Moscow we had discussed together with a representative of the plant the type of machine to be chosen. I had proposed the welding tractor. Now, at the plant, I felt sure I had given the right advice. The welding tractor had swiftly won recognition and was being successfully used.

After my trip to this plant I understood what Malishev had meant by saying it would soon be "hot" in the Urals. Here we shall unfold our main arsenal; here, too, the large-scale industry of the South will move if need be.

2. WHERE DO WE BELONG?

On July 2, 1941, I returned to Moscow. The reports from the front brought no comfort. The enemy continued to drive eastward.

In the ten days of my absence the capital had changed beyond recognition. It lived a strenuous and disciplined life. Of course, there were some people who were perplexed and who wavered in the face of the events. But these were few; I saw firmness, resolution and courage everywhere.

I refused to go to Kiev. We had to make a very urgent decision as to where to transfer our institute.

"What do you think of the southern regions in the East of the country?" I was asked in Moscow.

"It's tempting," I answered. "There is plenty of sun and fruit there, but it won't do. We want to be where they will immediately begin producing arms and ammunition."

Having made up my mind I telephoned the institute in Kiev. My family was no longer there: it had left for Ufa together with the families of other academicians on July 2. I ordered to prepare all people and all valuable equipment for evacuation.

My colleagues were worried:

"All the equipment? Will there be enough waggons?"

"Moscow promised to help."

"Where are we going? Some say Central Asia."

I resolutely rejected these proposals:

"This won't do. Our place is in the Urals, the centre of heavy machine-building. There we shall work at full speed for victory."

In my application to the Government Evacuation Commission, I named the exact city in the Urals and the plant we wanted to be transferred to. I intentionally avoided Sverdlovsk and Chelyabinsk—large industrial centres, which had many of their own scientists, and chose a new industrial area where the need for us was much greater.

I was told at the Commission that my request had been granted, that they hailed the desire of the institute staff to work in an industrial area and to make a major plant our base. They promised to meet me halfway in everything I would undertake.

They kept their promise. Despite all the difficulties of the time the People's Commissariat of Railways gave us 20 goods waggons for moving the institute. On July 12, I already had all the documents in hand and telegraphed Kiev about it.

On the day before I addressed a conference of the All-Union Scientific-Engineering Society of Welders, called by its chairman on my suggestion.

"We have few skilled specialists in welding," I said. "Each of us knows many enterprises, located far from the centre, which are in great need of such specialists. It is therefore important that we render effective aid to the

country in these days of war by our knowledge and experience. Each and every one of you must display some initiative and choose a plant where you can be useful, and see to it that you are sent there. Our institute has already made the choice. We are going to the Urals. You cannot confine yourselves to the role of consultants at the plants; you must take upon yourselves definite tasks and be responsible for them.

"I know not all members of the Society can leave Moscow for long periods of time. Such people might unite into some sort of a committee and continue with the work without leaving Moscow. We must get in contact with the People's Commissariats and enterprises, which do welding work, and help them with advice and designs. The committee must not wait to be called upon, but must itself operate actively."

All of my proposals were approved.

The rest of the evening and part of the night I had to spend in a bomb-shelter.

The fascists were making a furious drive for Moscow from the air. Their night air-raids were becoming more frequent and violent. A continuous wall of anti-aircraft fire barred the way to the Hitler flyers, everything around shook with the explosions of the anti-aircraft shells and the machine-gun bursts from our night fighter-planes. On the house-tops the Moscovites extinguished the German incendiary bombs.

In the bomb-shelter I was wondering what I could do to increase the production of air-bombs.

I had hardly slept that night; in the morning my proposals were ready and I took them to the proper organizations. A day later I wrote a memorandum to the Government on automatic high-speed welding of air-bombs. My proposals subsequently played a very important part.

I left Moscow on July 19, upon receipt of information

from Kiev that the institute had started on its long journey the day before in waggons placed at its disposal by Moscow.

On the way to the Urals I stopped at Ufa for my family. There I found many Kiev scientists. My story that the institute would do its work at the Urals plants aroused keen interest. We were envied. I advised all my colleagues who worked in engineering to do likewise.

The overwhelming majority of the scientists of the Ukrainian Academy of Sciences were very anxious to give every ounce of their strength to the defence of our socialist Motherland. The behaviour of one "resourceful" professor caused general resentment. He was trying to get a few jobs at once with the highest possible salaries and the best rations.

In Ufa I met A. Bogomolets, the President of the Ukrainian Academy of Sciences. The meeting was very cordial and we talked for more than an hour. I told him of our plans, of what we were going to do to introduce automatic welding at the plant and of our hopes of obtaining the aid of the plant in setting up a welding laboratory and a shop.

"Does that mean that you intend to do all your work at only one plant?" Bogomolets asked.

"Not quite. We intend to do that only to begin with in order later to make our experience available to other enterprises, while the plant must remain the principal base for our research and the initial check-up on the equipment, apparatus, etc."

"That's fine," Bogomolets said, "I believe our other technical institutes should also organize their work in a similar manner."

It was no easy matter to get to the Urals from Ufa at that time, and each day of forced idleness seemed interminable to me. I was therefore very happy to meet a technician who was taking a group of Kiev builders to the

Urals. We obtained a carriage and coupling it to a goods train departed. My family went with me.

Our goods train invariably had to give the right of way to trains with more important and urgent cargoes. We were dragging along intolerably slowly. I suffered on account of this and feared that my institute colleagues would reach the place ahead of me. We were moving directly north, and nature was growing more rigorous with each passing day. When the train crossed rivers, I looked at the bridges inquisitively. Some of them were my "old friends."

3. NOT SIDE BY SIDE, BUT TOGETHER

A surprise awaited me at the plant. The "advance detachment" of our institute was already there.

These colleagues of mine managed to get to the Urals in a rather unusual way. In 1939 our institute designed a light-model welded goods waggon which was built in Kiev. The waggon was intended for vibration and shock tests and, naturally, was not allowed to run on railways. It was in this experimental waggon that our institute workers managed to travel safely all the way to the Urals.

Now they were telling me how adroit and resourceful they had to be in order to get here, since at each transfer to a new railway this "illegitimate" waggon was uncoupled and either abandoned on the tracks or driven onto a siding.

I ardently shook hands with the first comrades who had arrived from my native Kiev.

"How are they treating you here at the plant?" I asked casually.

"The administration does not seem to be very happy about our coming," Dyatlov answered me for everybody.

We went to the plant together and I ascertained, much to my regret, my comrades were right.

The plant was subordinate to an organization for which we tested various grades of low-alloy steels. Compared with the steel of low carbon content, these steels were stronger, which enabled the plant to curtail the expenditure of metal and reduce the weight of the manufactured items. The instructor of our institute, who had put one of our machines in operation, had been well received and his work had been appreciated.

But despite these old connections, the director of the plant received us rather apprehensively.

He had his good reasons for it: at the time the plant was under construction it was visited by numerous representatives of several scientific-research institutes. According to the director they had worked very poorly, but had consumed a lot of money. And though there were no such complaints about us, the director was rather afraid to take a whole scientific-research institute under his wing.

A scientific institution at the plant? It is neither customary nor very comprehensible. From casual hints and ambiguous statements I guessed what was what. The people here, apparently, reasoned as follows: "We're fighting a war and we must therefore expand our production; but these scientists with their projects, far removed from the life of the plant, will only be in our way, will take up our time, distract our attention and upset the fixed rhythm of production."

Nonetheless, we were taken on, were given rather modest premises for our institute and lodgings for ourselves. We stayed on at the plant. I realized it was only formal recognition and that we would still have to win authority.

The plant was located in a big forest within eight kilometres of the city. This immense enterprise had

shops half a kilometre long and the most modern machinery.

The settlement, situated in a forest clearing, grew from year to year and the forest retreated farther and farther. The central part of the settlement was made up of fine multi-storey stone houses, which would do justice to any street in Kiev. I was lodged on the first floor of one of these houses. The family of an officer, who was at the front at the time, willingly made room for us. They gave us a small room of 16 square metres, but at that time hardly anybody could think of special comforts.

At first we were only four in the family: my wife and I, my wife's sister Olga and my son Vladimir. (Until November 1943, Vladimir worked as a technologist at a metallurgical plant where he had been sent upon graduation from an institute in Sverdlovsk; he was later transferred to our institute.) In January, 1942, our family grew to five: my younger son Boris, who was graduated from the Kiev Polytechnical Institute in the beginning of the war, was transferred from the Krasnoye Sormovo Plant to the Institute of Electric Welding.

In order to make the best of it in one small room we had to perform intricate daily manoeuvres with the furniture, taking our folding cots out in the corridor in the morning and bringing them back into the room for the night. The whole life of the family was closely linked with the plant; even my wife's sister, an old and experienced pre-school teacher, worked at the plant's kindergarten.

Boris was an electrical engineer, but to be useful to our institute he had to master the elements of welding first. From the very outset I asked some of our more experienced people to teach him. I brought my son to the laboratory and said to him:

"Learn to weld. Here is the wire, here are pieces of metal and here is some flux in the bucket. Your comrades

will help you get on. Later you'll have to teach others yourself. Don't forget it."

Boris was no exception; many people did likewise at that time. Before the war Arseny Makara had worked on shrinkage stresses, Danil Rabkin—on fighting corrosion, Georgy Voloshkevich—on the electrical part of the machinery, Sophia Ostrovskaya designed machinery for point welding, etc. In the Urals they had all become technologists, welders and experts in the production process.

From our first days in the Urals I pondered the problem of where and how to place our institute.

We were offered premises in the settlement. At first sight this appeared quite natural since the plant was close by. And yet it was only "close by." We wanted to help effectively and daily directly in the shops. That would have been the most valuable to both the plant and ourselves.

I came to the conclusion that the institute should not be placed at the settlement, but on the territory of the plant, in one of its buildings adjoining the shops.

The plant administration agreed with my reasoning, though to find two or three rooms for us proved a hard problem. Later I repeatedly convinced myself that my foresight was fully justified. We were always together with the plant, in the very thick of its life, interests and concerns, rather than only close by.

The train with our workers and equipment arrived from Kiev on August 11. First it was driven up to the settlement where our workers were given lodgings, and at night it was moved to the plant. I went there early in the morning and saw Makara, one of our young workers, near the train. He stayed on duty, while his companions were all taken away by representatives of the plant to their lodgings, prepared for them beforehand.

Makara and I greeted one another as if we had not met for at least ten years.

"Is everybody well?"
"Yes, everybody is."
Makara did not like my looks; he thought I had grown somewhat thin.
I immediately asked Makara to go through the train with me and examine our equipment. We crawled into one waggon after another, but found very little to be happy about. Only here and there did we see the shiny sides of welding transformers and the tips of automatic heads sticking out of a few crates.
"There's very little equipment, much less than I expected," I said to Makara. "Could our people possibly have thought only about themselves and their families, neglecting the institute and its future work in the Urals? Where is our laboratory equipment? Where is the machinery of our experimental shop? Where is the library it took us years to collect?"
Makara tried to reassure me. It seemed part of the equipment had been sent by water together with other property of the Ukrainian Academy of Sciences before the arrival of the railway waggons.
"That's different. But when will we get it? And will we ever get it?"
Under some pretext or other Makara looked away. He very obviously did not want to see the tears in my eyes, whereas I could not keep them back. I was grateful to him for his tact.
"Well, then, let's start unloading," I suggested.
I was angry with myself for having betrayed my momentary weakness.
"You don't mean it!" Makara cried out. "Our workers and some of the plant's people will soon be here to help us. These things are too heavy."
I did not want to waste any time and insisted on having it my way. But the two of us could hardly move a single crate. I soon had to give up the idea because in

this work I was rather poor help to the heavy-set and robust Makara.

I mused over the situation pending the return of our institute workers from the plant's settlement.

It looked as if we would have to build and collect our equipment all over again. I hoped we would get our property sent with the Academy. After travelling a long and arduous way by rail and water part of our equipment, finally, did arrive, though some of it was lost and some was badly damaged in the endless transfers.

Makara walked sullenly beside me, and I was almost sure I apprehended his thoughts.

"Regret your coming here? Think you should have gone directly to the front from Kiev, don't you? Be frank now."

"To be honest with you, I do," Makara confessed.

"Well, then, don't regret it and don't eat your heart out. As a specialist you will probably do more for our victory right here than you would have at the front."

"Here?" Makara grinned.

"Yes, here. You can take my word for it. This place is going to play a special part in the war. As to the part each one of us plays depends on ourselves."

I'm not sure Makara agreed with me that morning, but subsequently he and his comrades regarded their work in the Urals as the soldiers did their service at the front.

The personnel situation was no better than that with the equipment. Many of our workers had gone to the front. The staff of the institute thinned out noticeably. Of the four heads of departments only Dyatlov remained. Many of our senior scientific workers were away. Of the old guards, who had marched with us since the institute had been born, only very few remained. The department of automatic welding, which was now fated to play the

principal part, was visibly weakened. As to the workers of our experimental shops, not a single one was left.

It was clear we would have to reorganize our work for the war needs thoroughly and at the same time restore our institute with the aid of young people. That did not disconcert me, since it was not the first time I had started things with young people. Besides, I had always loved and, I dare say, could work with them.

The day after the train with our equipment had arrived I spoke at the meeting of our institute workers and laid before them our new tasks as I saw them:

"We are at one of the largest plants with other giant plants all around us. Here is the smithy of the country's defence. This is no time for work 'in white gloves,' in the seclusion of studies and laboratories, especially since we have never done that. The plant needs our help right now and it can't wait. We must roll up our sleeves and do any 'dirty' work, even as foremen, adjusters or instructors in shops, if we have to. We must find our place at this plant, introduce high-speed automatic welding on a large scale and win recognition and prestige. Our next step is work at other plants, and the more of them the better.

"We shan't draw up a thematic plan in the former sense of this word. Our principal attention shall be devoted to the war plants. We must no longer divide our forces. We must concentrate on our main problem: the introduction of high-speed automatic flux-welding in industry.

"This is our general line and we must find a concrete application for it. We shall not wait for the plant to come to us with requests and orders. Let us go to the shops ourselves, find out what they are working on and see what we can do to help them. You have three days for it. You have no right to procrastinate, to rely on others, on

the administration. Our country, the front must have the results of our work as soon as possible."

Most of the participants of this first conference responded enthusiastically. They were anxious to find real work and did not fear the hardships or the unusual nature of their new duties.

There was no unanimity, however.

One of our leading workers (I don't want to mention his name since he subsequently did his best to correct his mistake) opposed the "transformation of the research institute into a shop of the plant." He expressed his discontent openly:

"They want to make factory-hands out of scientific workers. We have our own problems, but if we enter on this path we shall lose face."

This worker voiced the opinion of two or three more people. I thought his grumbling merely concealed a lack of understanding of the danger that threatened our Country and the "peace-time moods" that the Party called on us to give up.

It was in this spirit that I answered my critic, though I realized that words alone were not enough to make him change his mind, that life itself would have to cure him of his harmful arrogance. And still I had to censure him immediately and harshly.

We really had very few people then: only eight senior scientific workers, as many junior ones and two engineers. So much the more was it necessary to put them in action right away.

Our shop campaign immediately helped us find out where we could be most useful.

The electrode shop barely supplied the plant with quality electrodes since we lacked some of the requisite components for their manufacture and, what was the most important, we were deprived of the Nikopol manganese ore. Our workers swiftly produced substitutes for

these components from local Urals raw materials. Another group of our workers improved the technology of welding in the manufacture of the principal commodities of the plant. We began to be regarded as useful people.

We wanted to do much more and on a larger scale. I offered the chief engineer of the plant and the chief designer to introduce resistance point welding to weld the thin plating to the frames, and to design several new machines for welding certain joints.

Some people at the plant gave us their support, but did so only in words. It was, apparently, due to the fact that the plant had enough manual welders at the time and fully relied on them. Besides, the people at the plant did not particularly care to look ahead.

Our first mishap did not discourage us. Some of our workers visited a shop which was already working for the front, welding the bodies of air-bombs manually.

On seeing this I told my assistants right away that was just what we needed.

After being turned in lathes the halves of bodies were given to manual welders. We could certainly supplant them with our automata and sharply raise the productivity of the shop. I had thought of this even back in Moscow.

I went to the chief engineer:

"Give us a chance at bomb-welding. We're not asking for anything, we'll do everything ourselves. We'll set up our automata next to the manual welders, and then it's up to you to decide what suits you best."

The chief engineer agreed. He was running no risk.

In September, 1941, we began constructing our two machines. There was no shop, and we had to use the available parts intended for an entirely different purpose. Our machines were not much to look at, but they had been produced fast. We made our own electric installa-

tions for the automata in the shop alongside of the manual welders, and Oleinik, our instructor, immediately set about mastering the technology.

And still we could strike up no friendship with the shop. The blanks were all given to the manual welders, and the automata stood idle. The production plan was fulfilled without them, and it never occurred to anybody that the plan might soon be doubled or tripled. The shop administration lived quietly and regarded the automata as foreign bodies.

I gave them an ultimatum:

"Either the automata get work or we discontinue our efforts."

My threat failed to scare anybody. Everything remained as it had been.

That took place at the end of 1941, but a year and a half later, in July, 1943, the administration of the same shop asked us to help them by designing a machine for welding new-type bombs.

The shop now had to produce them in enormous quantities. They were the same people but very much embarrassed this time.

A good old Russian proverb says: "Let bygones be bygones." We did not care to recall the past, but designed a machine and even partly manufactured it. Life showed who had had greater foresight. Here our first experience, our first successes and failures stood us in good stead.

4. HERE, TOO, IS THE FRONT

On September 21, the radio brought us incredibly painful news: our troops left Kiev...

A dead, oppressive silence hung over the institute that day. In the eyes of the people I could read keen and sincere sorrow.

The fascists are in our Kiev; the Hitler boots are treading the streets of the beautiful city! It was impossible to reconcile oneself to this idea or to get used to it.

Every nook and corner of Kiev rose before my mind's eyes, and a sharp pain pierced my heart. I could see the graceful and distinct contours of Chain-Bridge for the restoration of which I had given all my knowledge. Looking through an English magazine much later, I came across a picture of the bridge over the Dnieper. But the picture showed only lonely piers sticking out of the water. The fascists were relentlessly destroying all we had created by our labour.

Days and weeks passed; time did not alleviate the pain; the voice of consciousness prompted: you must work even harder and with greater devotion to bring closer the day of liberation of Kiev and all territories seized by the enemy, to bring closer the hour of final victory.

In the meantime sad news came from the front—the fascist armoured hordes continued to move eastward.

It was October, 1941. The country was having a hard time. The enemy was driving towards Moscow—the heart of our Motherland. The fascists blared all over the world they could see the suburbs of the capital through field-glasses. Hitler boastfully named the day of his triumphant entry into Moscow. To be sure, he constantly changed the date, but the danger was really very serious.

We lived in constant anxiety. A tremendous battle was being fought on the snow-covered fields near Moscow.

We were sure, however, our dear Moscow would never be surrendered to the enemy. The faith of all our people in victory was also our faith.

It was at that time that the plant was ordered to stop work and remove part of the equipment in order to make room for another plant evacuated from the Ukraine. Only one shop producing air-bombs remained.

E. Paton with tank-model presented to him by the personnel of a tank-plant

We soon learned the Government ordered the evacuated plant to launch immediate production of tanks.

From now on we were to work at one of the largest tank plants in the country. What else could we have dreamt of? Where else could high-speed automatic welding show itself so well during the war?

Life at the Urals plant instantly came to a standstill. We saw how the equipment, useless to the new plant, was dismantled and removed.

The work was being done at a feverish rate, and still it seemed it would require at least half a year to bring life back into the deserted shops.

The crash of metal had never ceased here, but now an amazing silence descended suddenly. I was particularly surprised at the chirping of sparrows, since formerly it had been necessary to shout to be heard within two paces Heavy cranes moved overhead carrying the dead machines and loading them on trucks driven directly into the shops.

How long will it be before the trains, bringing the Ukrainian plant, make their appearance on the railway branch leading to our plant?

In the middle of October the main shops were deserted. At about the same time we heard in the streets of our settlement sonorous Ukrainian speech, merry jokes, loud laughter of our countrymen, who never lose heart anywhere. The first trains had arrived at the station. I went there. You can imagine my joy when I discovered that the newly arrived plant was one with which we had had very friendly relations before the war.

All of the side-tracks were now crowded with trainloads of equipment. People sat on their bags all along the trains. Engineers, technicians and workers came to the Urals from the Ukraine with their families and were immediately given lodgings. The Urals people received the Ukrainians as brothers and shared all they had with

them. Nobody thought of the hardships he would have to endure.

One plant was moving to a new place, another plant was taking over its shops. The movement of hundreds of machines and thousands of people proceeded according to a single and well thought-out plan.

The new plant was being assembled day and night. Fires blazed on its territory all through the night. The workers forgot about sleep, rest and food, and worked 12-14 hours on end, sometimes staying at the plant for several days running. The plant was growing before our very eyes.

While some of the equipment was still being set up and assembled on its foundations, outdoors, under the open sky, in freezing weather, workers and engineers assembled units of the first Urals tanks. The armour plates, unloaded here from trucks, were cut, processed and welded there and then.

The country could not wait a single day, and the Government demanded that the Urals begin to produce tanks at once. The heroes at the front had every right to expect the same selflessness from the workers in the rear.

Then came a fair cold day in early January, 1942, which I shall probably never forget. Raising clouds of snow-dust a powerful tank rumbled out of the delivery shop and sped down the plant road.

Less than two months passed between the arrival of the Ukrainian plant and the birth of this tank.

People lined the plant road and joyfully watched the snow, flying from under the caterpillars of the tank built by their labour.

I rejoiced together with them and thought of the iron will and the brilliant organization it required to move hundreds of plants east in so incredibly short a time and put them in operation.

On December 6, 1941, the Soviet troops launched a

counter-offensive near Moscow beginning the rout of the fascist hordes in this area. It was only a month since our troops had gone into battle right from Red Square, from the very walls of the Mausoleum. Only one month and the glorified Hitler warriors were fleeing in panic, abandoning everything and leaving town after town, region after region.

The first major victories of the Soviet troops and the first tank born in the Urals. I realized both these facts were engendered by a single force, and I felt this force was invincible.

We established friendly and business-like relations with the administration of the plant from the very outset. I knew Y. Maksaryov, the director of the plant, as a competent engineer and a leader of extensive experience. He now shouldered a great responsibility—the plant had to produce medium tanks on an enormous scale. Maksaryov was aware of the forthcoming difficulties and did not hide them from me.

"For the time being the plant is getting ready-made hulls from elsewhere," he said to me, "but this won't last very long. Our armoured-hull department lags behind because of our manual unproductive labour. Do you know the hull of a tank has dozens of metres of seams of large cross-section? Here is only one example: to weld the side to the caterpillar protection plate requires two 5-metre seams. Manual welding takes a lot of time and hard work. We need hundreds of skilled welders, which we can't get, whereas of those we did have many had gone to the front."

"I can see it all very clearly," I answered. "Our only salvation lies in high-speed welding. Here is my reply to your example: the seams you mentioned will take an experienced welder approximately twenty hours to weld, whereas our automaton could do them in an hour. And the automaton can be operated by an adolescent."

Maksaryov smiled:
"We don't have to persuade one another. I can see the following perspective: first your automata will work on welding separate units and later the entire hull, I hope. I guarantee your institute the most vigorous support and expect real, and what's more important, swift help from you."
I went away greatly inspired.
We were now facing a severe and responsible test. We were working at a plant which was to give the country thousands, maybe tens of thousands of tanks. But we had only the faintest idea about welding armour steel. We had but recently experimented on small samples and here, the whole yard of the plant was crammed with armour plates.
Some of our people were at a loss and I even heard them say:
"Will we be able to cope with it?"
"We aren't ready as yet to answer the questions which the tank-builders will inevitably put to us..."
Most of our people displayed a fighting spirit, though; they saw before them the goal which was worth working very hard for.
In November the plant was visited by Malishev, who was the People's Commissar of the Tank Industry at the time.
He issued an order instructing the directors of the plants to introduce automatic welding in the manufacture of tank hulls.
This order gave us an opportunity to launch extensive work. We started intensive preparations. Introduction of high-speed welding required equipment first of all. We did not have it. The plants, which had introduced automatic welding before the war, had already moved or were now moving east. It was impossible to get their welding machines for the tank industry. I wrote to the Avtomat plant which had produced welding heads before its evac-

uation from Kiev. The plant could offer us only one head. Hence, we could not rely on anybody and had to start with whatever few things we had at our plant.

Together with Sevbo I looked through the album of machines designed before the war.

"We have to admit," the chief designer said chagrined, "these machines are no longer fit for mass production. They are cumbrous and hard to manufacture."

I anticipated Sevbo's resistance and was now glad to hear his critical remarks.

"Look at the disparity between the miniature size of the welding head and the massiveness of the component parts of the machine. This is where you will have your say, I think. Life demands that we build a new welding apparatus which should be universal and at the same time as simple as possible."

Sevbo fully agreed with me and set to work. We had thought out the scheme and now he worked fast. At the end of November the drawings of a new high-speed welding apparatus were handed over to the shop.

We ventured to manufacture the first apparatus in our own shop.

Some mention should now be made of the shop and how it came into being.

The difficulties we had encountered in manufacturing our first machine for welding air-bombs made us feel we needed our own production base, however modest. The plant was in no position at the time to give us machinery or workers and all we had was a single lathe that had remained from our Kiev shop. Then we tried to get some equipment by hook or by crook. The old plant "cemetery" was our main source of supplies. There we dug up several lathes which had long since deserved "eternal peace." We also managed to get some few things in the shops. We put all our trophies in a semblance of order and installed them in our laboratory. The late A. Sido-

renko, senior scientific worker at the time, was the principal booster.

We now had some sort of machinery. But who was to operate it? Where were we to get turners, milling-machine operators and planers? We issued an appeal and 15- and 16-year-old boys, children of our workers and employees, appeared in our shop. They were all clever and shifty fellows, but they had no idea of machinery at all.

This "mechanized kindergarten" was headed by our laboratory technician M. Sidorenko, in the capacity of chief turner, and another laboratory technician, L. Bogachek, as chief fitter. They were learning themselves and teaching the boys. The "honoured" veteran machines, operated by the adolescents, soon began to produce apparatus for tank welding.

It was in this shop that our first high-speed welding apparatus "came off the conveyer" at the end of 1941. It looked quite impressive against the background of its small-stature builders. In the beginning of 1942, the plant was visited by the People's Vice-Commissar of the tank industry. I gave him a demonstration of the latest achievement of our designers. The apparatus, suspended from a small scaffold-bridge, enabled the electrode to work in any position and propelled itself along the welded item.

Our apparatus met with approval. The People's Vice-Commissar was surprised we had been able to "produce" it in our primitive shop and ordered the chief mechanic, there and then, to manufacture twenty of them. The plant made all the blanks for them and we finished them in our shop. By May 1, we had manufactured the first two high-speed welding machines and installed them in the shop. It was thus we celebrated our traditional May Day in the Urals.

5. WE LEARN TO WELD ARMOUR

A model of the Soviet medium tank is still standing on the work-desk in my office. It is a memory of the unforgettable war years, a valuable gift I received from the personnel of the plant.

Before the war I had seen tanks only at parades in Kiev and in Moscow. I had always marvelled at the power of these machines, but I had had a strictly civilian idea of them. I could hardly tell the difference between a medium and a heavy tank. I had had much better knowledge of steel structures, carriages and tank-cars.

And here we found ourselves at a tank plant which played an important part in the plans of the Soviet High Command. On Maksaryov's desk I saw a special telephone which rang two or three times a day. Picking up the receiver Maksaryov was ever ready to report to the Government how many tanks had left the plant each shift.

At that time our city acquired the name of Tankograd (Tank City).

Redoubtable, armour-clad machines roared day and night past the windows of our homes.

Around the plant and near the vegetable gardens the earth was dug up by tank caterpillars. Every road showed deep ribbed imprints of steel tracks.

In the streets we could often see smartly uniformed N.C.O.'s—cadets of a tank school. We knew these were the men who would fight the enemy in our machines.

When the wind blew towards the city, we heard gunfire—testing the armoured hulls on the proving-grounds.

Nearly everybody here considered himself a tank-builder and rightfully so. We were also becoming tank-builders. People always said I was "in a hurry." It was true, but not to be in a hurry now would have been a crime.

I made the following demands on all our comrades:

"First of all we must give up our 'civilian' ideas of tanks, the detached ideas of guests at a parade. We must study the tank and what it is supposed to do in battle; we must get an insight into its 'soul.' Which are the most important seams? Which of them are most frequently hit by the enemy? Which are the most vulnerable spots in the tank when it attacks or rams the enemy? We have no idea of any of this, but we must, because all this directly concerns us as welders."

We had to weld seams, and it was important to know what they would encounter in battle. We studied the tank seams, their arrangement and purpose, and soon they were no longer merely abstract lines on drawings to us.

The question was: what could we do to make the seams stronger?

We had to flux-weld the armour with our automata and elaborate a completely new technology. It was no easy task, since we had had no experience and were actually doing it for the first time.

Intensive research work was begun in the laboratory of the institute. A great deal in our past practice had to be reconsidered and rejected.

Cracks in the seams of the armour! How to get rid of them? The cracks could not be seen with a naked eye; they could only be detected by a microscope, and not always at that. The minute, invisible serpentines thinner than a hair.

They may not be observed by the strictest and most exacting receiver of the war department, but there was another controller, much more dreadful—the enemy shell. The viability of the tank, the safety and lives of Soviet fighters depended on these damned cracks.

I thought about this continuously. I visited the welding laboratory where Dyatlov and Slutskaya together with an engineer from the plant conducted their stubborn struggle against the cracks. An outsider could hardly

apprehend the importance of their work. They employed different kinds of electrode wire, covered the welded place with flux of various composition and varied the welding regime.

It was outwardly unnoticeable and prosaic, but exceptionally important, research work. They worked ten-twelve hours per day and all to no avail. The hated cracks kept discrediting the welded seam. Dozens of ground-ends had been made, but the results were not comforting.

We had no right to despair. To lose heart meant to give up armour-welding.

After long searches we hit upon the right idea. The first experiments brought us both joy and disappointment. We attained the desired results, but the speed of welding dropped sharply. The latter upset us, but we acquired the confidence we were on the right track. We had now reached the stage when the proposal, submitted by Dyatlov and Ivanov, to use addition wire—could be considered. It was a happy idea. We repeated the experiments with the addition agent many times first in the laboratory and then in the shop. At last we had crackless seams and more productive welding.

We had now acquired faith in ourselves. While three of our people worked in the laboratory, our young workers—Makara, Korennoi, Ostrovskaya and Voloshkevich—perfected the technology of armour-welding directly in the shop. We no longer worried about the behaviour of our seams even under heavy fire.

We have always been proud that the Soviet tank-builders were the first to learn flux-welding of armour.

The Germans had no automatic welding of tank armour till the very end of the war, while the Americans had used it only since 1944. I was always interested in what was doing in this field abroad. Our plants often received smashed fascist tanks for resmelting. Their seams were

welded manually and very poorly. We made analyses, macro- and micro-ground ends, which showed that the seams, as well as the armour steel, were brittle and offered poor resistance to Soviet shells. The Germans, obviously, paid little attention to the quality of the armour and the welding, but strove to produce more tanks in order to scare us by their numbers.

6. THE INSTITUTE WORKS IN SHOPS

At last came the day when we had to show what our automata, and consequently we, too, could do.

Soibelman, chief of the armoured-hull department, set the day for test-welding. We refitted the two machines, which had remained from the Urals plant, and adjusted them to welding the sides. The sides had long, large-cross-sections seams and high-speed welding could show itself to the best advantage.

As I've already mentioned we had made laboratory experiments dozens of times. But whereas we formerly practised on pieces of armour, we now had a real side of a tank with several metres of continuous seams.

The first side was welded under solemn circumstances.

Besides us, the workers of the institute and the plant administration, a crowd of curious people gathered around the machine; nobody had ever seen this before. By force of habit many of them came with protective glasses, but they did not have to use them. A bridge-crane stopped directly over us and the girl-operator looked down from her cabin; several adolescents, working in the shop, made themselves comfortable on the crane-trusses.

I, too, yielded to the general excitement. I had designed hundreds of important structures in my long life, but at that moment, I confess, I was excited and nervous.

One of the welders of the plant switched the automaton on.

As if to spite us, the arc did not ignite right away, and it took our instructor a minute or so to fix it. This was being done during the lunch hour and in the tense silence we could distinctly hear the welding arc crackle under the flux. Invisible to the eye it melted the metal.

What goes on under the layer of flux?

This can be judged only by the monotonous and characteristic crackle of the arc and the tremble of the voltmeter hand, which registered the course of the process. Everything was in order: the truck confidently moved along the seam at the fixed speed.

Large beads of sweat sparkled on the welder's forehead. Mechanically I passed my hand over my face and my hand got moist... Take it easy now, I said to myself. So far there hasn't been a single break in the arc, no splash-out, no electrode "freezing."

Turning the automaton off, the welder knocked off a piece of crust formed by the flux:

"There you are!"

We beheld a flawlessly smooth and beautiful silvery seam. No pores and no blisters.

I drew a sigh of relief while somebody behind my back exclaimed with delight:

"What a beautiful seam!"

But, as usual, there was also a doubting Thomas in our midst.

"It's too smooth; looks like tin. Let's see if the seam will hold," he muttered and hit the seam with a chisel.

The seam did hold. The arc had connected the edges of two armour-plates with a firm and uniform seam.

We heard congratulations on all sides, but were hardly aware of them, since the nervous strain had taken a great deal out of us.

I left the shop. It was a cold January night. My

co-workers stood beside me. Tanks with manually welded seams sped past us.

There was a lot of hard work ahead of us. We realized the success of the day was only the beginning.

A week after the first machine had been put in operation I was visited by Demchenko, the superintendent of the shop. He came right to the point:

"Well, Comrade Paton, I'm all for it, you know, but let's be business-like about it. Two machines can do all the work on the sides, but we need people, instructors capable of swinging the whole thing. We have no such people and you must give them to us."

I liked his straightforward talk, though the problem he put before me was not an easy one. We did not have any workers, who could immediately go to work in the shops, either. Experienced instructors, who had put our machines in operation before the war, were far away, at other plants where automatic welding was being introduced.

"All right," I said, "you'll get your instructors. Not consultants, but practical workers. They will be responsible for the work together with you."

Demchenko was quite satisfied when he left me. He only asked me to expedite matters.

I gave my promise, but how was I to keep it?

I sent for the junior scientific workers. Before me were people who had come to our institute directly from college and had no idea of production. I went right to the gist of the matter:

"Starting today," I pointed at Makara, Korennoi and Ostrovskaya, "you are appointed as instructors to the machines for welding the sides. The rest will begin training in the laboratory for the same work and as soon as we have more machines they will also be transferred to the shops. There you will have to do everything and be responsible for everything. Whatever happens the

automata must fulfil the plan. Remember, high-speed welding is now taking its test in industry and it is doing it at a war plant."

I watched the faces of my young comrades, wondering if the responsibility would not scare them, if they would not try to find all sorts of excuses.

No, I was not mistaken in them. The first three took their new appointment in stride and were followed by the rest.

Our new instructors were transferred to the shops for permanent work.

They had their difficulties at first. With their as yet unskilful hands they adjusted and, when necessary, repaired the apparatus, patiently taught the plant's welders, cried themselves hoarse arguing with the foremen and crane operators who tried to pass up the automaton and move the assembled sides to the manual welders. There were not enough sides at that time, and the manual welders literally attacked them, ashamed of wasting even a moment of their time.

Many months later Ostrovskaya told us what she had experienced during the first night of her independent work in the shop.

For four days prior to that night she had practised on a laboratory machine. The automaton was unsteady and she was very much afraid of what awaited her in the shop. But there was no turning back. Courageously she took over the machine from Korennoi and with a cheerful and confident air set to work together with the plant's welder.

Much to her delight, everything went fine in the beginning: two sides were welded without any mishaps or complications. The instructor and the welder were satisfied with one another and both of them were content with the automaton. But all of a sudden, as Ostrovskaya was about to begin welding the third side,

the current-feeding tip burned out. She turned the current right off.

What was there to do? Stand still? Cover herself and the institute with shame? That was direct frustration of the plan!

The shift foreman came running to the machine. The situation had to be saved at all costs.

There was no spare tip in the shop. Without saying anything to anybody, Ostrovskaya ran to the institute laboratory. Behind its locked doors an old watchwoman was fast asleep. Ostrovskaya knocked on the door for all she was worth, but to no avail. She broke into the laboratory through a window and on her own risk took the tip off the laboratory machine.

Half an hour later the head of the automaton was already crawling along the third side.

Upon learning about the accident, I issued an order strictly prohibiting the "squandering of any laboratory property," but did not name the culprit for obvious reasons. Had the plan been frustrated, I should have censured Ostrovskaya very strictly.

I asked the instructors to keep a special record-book for each machine. In these books they marked the productivity of the automaton and the quality of its work, registered all defects, breakdowns and stoppages, as well as the reasons for them, and the complaints against the shop or the plant. I checked on these notes at the most unexpected time, appearing in the shop at night and comparing the instructor's appraisal with the situation in the shop. Later, during the conferences with the director of the plant, I always had all the information I needed, was fully aware of the situation and did not have to ask anybody for anything.

I must say that whenever anything serious happened in the shop they telephoned me regardless of the time

of day, and I never failed to go there on the very first danger signal.

For trips to the plant I had "my own turn-out"—a wicker cart on excessively large wooden wheels with iron rims. At the bends in the road the cart careened sharply, and I always wondered why my coachman (my coeval) and I never turned over. This cart, which everybody at the plant knew very well, invariably evoked smiles on the faces of passers-by. At night and on Sundays I walked because my "chauffeur" was off.

It took our instructors only a short time to master the situation in their shops. Formerly the foremen regarded the automata as amusing toys, but now they began to consider them as their principal source of power. They were already wondering, as the shop superintendent did in his time, if it were not possible to replace all manual welding by automatic.

A group of twelve manual welders worked next to our automata. Our two machines successfully competed with them. Three weeks later I said:

"Let us do all the welding of the sides. Isn't that what you wanted? We'll be able to do it all ourselves."

Demchenko, the shop superintendent, compared the work of the automata with that of the manual group. The resulting picture was sufficiently convincing. The automaton was eight times as productive as a manual welder. One machine operator replaced a whole group of skilled manual welders. We could immediately let go twelve workers whom the plant needed very sorely.

"We are very thankful to you," said Demchenko, and the group was transferred to other shops where there was no high-speed welding as yet.

"You'd better thank our instructors, they did it," I said.

One evening I was in my office entertaining a guest—a worker of the People's Commissariat, who came to us from Chelyabinsk. This tidily and cleanly dressed young

man was in charge of electric welding of the entire Commissariat. We were discussing current problems.

At this time Makara, Korennoi and Ostrovskaya came in to make their daily oral report (it was the practice at the plant). Tired, in their burned and patched-up overalls, they did not look very much like scientific workers.

It had been a very strenuous day and, appealing to the representative of the People's Commissariat, they complained of the difficulties with the flux and wire and the lack of order in the shop. Giving vent to all that grieved them, the instructors left.

Alas, my interlocutor had not noticed the ardour and sincere enthusiasm with which they had spoken of their hard work in the shops.

"Are they really engineers, scientific workers?" he shrugged his shoulders. "How filthy they are!"

I looked at him in unconcealed surprise.

"What's eating you? We're fighting a war, and these young people, as you see, are doing the best they can. It won't hurt their scientific work, I assure you. They are going through a hard, but very useful school. I'm proud of my assistants."

"Well, you know. . ." the guest faltered.

It was clear he did not understand me, so I changed the subject. This man was alien to our life.

I must say frankly life was very hard, especially for those who worked in the shops.

I remember a typical incident my son Boris told me about. At that time he had finished his "course of study" under the supervision of Ostrovskaya in the laboratory and was working in the shop. Like our other electricians, Boris personally did all the electrical work connected with the welding automata including all the unskilled work. He had to cut wire, assemble the machinery, solder the tips and carry on his own back the heavy apparatus and equipment to the point of assembly.

Hunched up under the weight of a roll of wire, Boris entered the shop one day, dumped his load near a welding machine and resumed his work. Engrossed, he did not notice an officer who had stopped at his side.

"Boris? Fancy meeting you here!" the officer exclaimed. "What are you doing here?"

It was one of Boris' friends with whom he had studied at the Kiev Polytechnical Institute and who, as a cadet of a tank academy, had come here for practice.

"I'm a scientific worker at the Institute of Electric Welding," Boris answered smiling.

"Come now, Boris! You are working as an electrician, aren't you?"

"I'm telling you I'm a scientific worker," Boris laughed. "We all work like this, combining theory with practice," he said, adding seriously: "We can't do otherwise. We must be able to use both head and hands. It's only by working like this with the people at the plant that you get to know what they want from science."

Boris learned from personal experience how right he had been. Only a short time afterwards workers from different shops began to consult him on serious electrotechnical problems.

Our instructors worked through the whole shift together with the welders, i.e., ten-twelve hours on end. Dozens of manual welders worked around them at that time, and the blinding light made the eyes smart. This was, what they called, "catch the arc." They wore dark glasses, applied eye-lotions made of strong tea. And still they had a feeling their eyes were full of sand.

Our people dreamt of catching up on their sleep, but that was well-nigh impossible since the plant worked seven days a week. Sometimes the young people went to the club after work to see a film, but many of them fell asleep there and then. For a long time the club showed a film in which the scene was laid in Central Asia. On the

screen we saw tempting, juicy fruit, to which we had preferred the severe nature of the Urals. This film was, naturally, very popular, and it gave birth to a current joke: "Let's go to the cinema and eat some fruit." But hardly anybody at the institute saw even this "tasty" film to the end. We were overcome by sleep.

I could not help deeply respecting our young scientists especially since I had never heard a single complaint or request to be recalled from the shops.

Our people worked selflessly and in harmony, doing even more than their hard jobs called for. If one of them had any trouble with his machine, the others gave up their rest and sleep and came back to the shop to help him out, never failing to report to work on time. Despite all their hardships, the young people of our institute were always cheerful and merry, never lost heart, never whimpered and preserved their sense of humour.

I was strict and stern outwardly, but deep in my heart I had a soft spot for my pupils, who had become so near and dear to me.

7. NEW POSITIONS

The welding automata were becoming an inalienable part of our daily life. The workers lighted their cigarettes on the red-hot flux-crust, while all, who worked in close proximity of the automata, considered themselves experts in high-speed welding.

High-speed welding at the plant was now being used on an industrial scale. I asked the plant administration to appoint a man who would be fully responsible for its further spread. Portnov, a young engineer and an enthusiastic and tireless person, was appointed chief of automatic welding. At our institute he had learned all he needed to master welding, swiftly entered into his role and began to "play the boss." Before issuing any orders

he usually consulted our workers, which saved him a lot of trouble.

Before coming to the Urals the plant had had two welding machines in the birth of which we had played our part. I had visited this plant in 1941 and saw there was a lot we could do there. On an order of the plant we designed a machine for welding an important unit. The plant immediately manufactured the machine and put it in operation. It brought two such machines to the Urals. We now offered our services in refitting them and putting them in operation. The chief of automatic welding also set to work with enthusiasm.

In a very short time the machines were installed and working—welding the heads of tanks. This was one more victory for high-speed welding.

The people, who worked on our automatic welding machines, frequently gave us cause for innocent merriment which we particularly appreciated in those days. One of the welders had studied singing before the war. He maintained his passion for the vocal art during the hard years of war. When things went well with his machine, he sang at the top of his voice either the Toreador Aria from *Carmen* or the Aria of the Duke from *Rigoletto*. But if something went wrong with the machine he changed his repertory, and the whole shop heard:

"Yevgeny, you're my friend no longer!" (By Yevgeny he certainly meant me, rather than the character from the opera *Yevgeny Onegin*.

Approaching the "musical machine" our instructors always listened carefully. If they heard *Rigoletto* or *Carmen*, they knew they were not needed, but, if the singer was wrathfully addressing himself to Yevgeny, it was a sure sign they had to rush to his rescue.

After the war this vocally-gifted welder joined a vocal ensemble.

Another welder had been a tailor before the war. He was particularly fond of his professional terminology and at first it was rather hard to understand him. For example, he would rush to the adjuster on duty and excitedly tell him that the "thread was breaking" or the "seam was wrinkled," which meant there were frequent breaks in the arc or the seam was not uniform and had bulges and overlappings. These people worked faithfully, oblivious of time.

The head unit with the visible seams on the finished tank was now fully done by high-speed welding. These seams were very important, since it is head foremost that the tank fights in battle.

Thus, in one shop, under a single roof, we had four automatic welding machines, more than we could have boasted of in peace-time.

But the machines we had in operation were seriously menaced. The apparatus, which worked faultlessly under the tranquil conditions of a laboratory or in the relatively slow rhythm of peace-time, now began to play tricks. It was clear that in our endeavour to automatize as many operations as possible we made our machinery too complicated. To rely on it under the present conditions, it was necessary considerably to simplify its electrical part. I had posed this problem soon after our coming to the Urals and now felt we could not let it go any longer.

The history of simplifying the electric schemes and the apparatus and of considerably increasing their reliability showed us that the close proximity to production was a powerful factor in accelerating production, since it spurred on our thinking and made us move and work faster. Under the ordinary peace-time conditions, prevailing in respectable scientific-research institutes, this work, based on certain plans and methods, would probably have taken one and a half to two years and we would have been quite satisfied with ourselves.

It all worked out differently now. In a short time we simplified the schemes of our machines. Instead of the "chiffonier with the apparatus," which terrified our shop electricians, we now had small apparatus boxes, which were reliable in work and simple to operate.

We now had to refit the automata in use. The shop administration agreed to stop them for twelve hours, which was a very short time.

We called the "state of emergency" at night. In the evening I went to the shop together with my co-workers. We did all preliminary work in our own shop, but, nevertheless, had a good deal of trouble before we could start the machines at the plant. On top of all our misfortunes the trucks did not run in their tracks after refitting. The designers feverishly searched for the causes.

We could not waste any more time. Excited foremen came running from the neighbouring sections. They demanded work.

"The 'Patons' are disrupting our programme," they shouted.

We were very nervous. The stoppage in our section disorganized the whole department. Finally, our emergency group found the trouble and eliminated it. The trucks were again installed at the beginning of the seams and the refitted automata began welding the sides.

The incident was soon forgotten and everybody in the shop admitted the simplified schemes had fully justified themselves. The machines no longer balked and never let us down. In June 1942, we switched completely to the simplified schemes; the two old welding machines acquired a companion in welding the sides, which was the fifth automaton in the shop.

Our instructors, who were introducing automatic welding at the Urals Machine-Building Plant, reported they had put two new machines in operation.

Our spirits were rising. We now had a branch at one of the largest machine-building plants in the country.

Tanks had but recently been welded only manually. We now began vigorously to displace manual welding wherever possible. The first results were already to be observed in the productivity of the hull department. We had to take the next step—to put welding on a production line. But neither we, nor the welders abroad had the requisite experience.

The director of the plant proposed to build an original, and singular for that time, conveyer for the manual welding of tank-hulls, using part of the Pullman trucks which had remained from the former plant.

We grasped at the idea.

"The conveyer is planned for manual welding, but I do not for a moment doubt our automata will find their place on it," I told our designers.

They joined their efforts with the workers at the plant and set to making draught designs. We soon saw the conveyer in operation.

It goes without saying this innovation speeded up the production of tank-hulls. The distinct rhythm made for strict discipline and kept everybody on his toes. To lag behind now meant to go back on the shop, the plant, the front and the country.

We liked everything about the conveyer save one thing: where does it say that the conveyer is good only for manual welding? Can't the automata demonstrate their superiority here, too?

A short time later they appeared on the production line. The automata welded the external seams, while the manual welders worked inside the hulls. This work was frequently done simultaneously.

It took the breath away to watch the beautiful, almost magic, picture of the tank-conveyer. At twilight, in the green flashes of manual welding, one could see the

mighty outlines of the moving trucks with the hulls. New parts were added to them on their way, and they grew increasingly majestic and imposing. I often watched them and thought of how little we had had to begin with.

All of us—the plant workers and the workers of the institute alike—were proud of our common creation. Whenever we had visitors from Moscow or other plants our instructors wanted to be the "excursion guides" and show them the conveyer. This was considered a great honour.

8. STORY OF THE BIRTH OF A CERTAIN FLUX

At the turn of 1942 the plants, employing automatic welding, began to send us anxious letters telling us their reserves of AH-1 black flux were coming to an end. They all wanted to know where they could get the flux to weld with.

"Do you realize," I said to Dyatlov, "that the uncertainty with the flux damps the ardour of the plants. I'm afraid they'll lose whatever enthusiasm they had when they started automatic welding."

"Of course, I do," Dyatlov answered. "There's real danger the plants will stop their machines and will go back to manual welding. But where can we get the flux for them? Where?"

We could not get it anywhere.

Before the war the Proletary glass-works in the Donets Basin produced the flux for the entire country, since it had a special melting furnace. The Proletary had now been evacuated inland and had discontinued the production of flux.

One of my co-workers gave me the following advice:

"What can we do, Comrade Paton? We must write and tell the plants that no flux is being produced."

This "advice" filled me with indignation.

"Your answer means you simply wash your hands and act like a bureaucrat. What good will all our work be if the plants have no flux? Besides, this will immediately tell on our troops."

Finally I hit upon an idea. I called all our technologists and spoke to them.

"We must find a way out of the impasse for our plants. We must immediately develop an unmelted flux from local Urals materials. Is there anything better than a simple flux obtained without furnaces or other equipment? I charge Dyatlov with this work, but all of us must help him."

Dyatlov was enthused over this plan.

We knew there were deposits of rose stone—rhodonite—somewhere in the vicinity of Sverdlovsk; it had been quarried before the war for facing the stations of the Moscow Metro.

We went to the Geological Committee in Sverdlovsk and with its aid found the quarry, which had but recently been worked. Now it was abandoned.

We took several pieces of rhodonite with us and at home we pulverized and screened it and then tested it on a laboratory machine. At first Dyatlov tried to weld under the pure fine powder, but the seams came out porous as a result of the isolation of moisture. After annealing the rhodonite the pores disappeared, but the seam formed poorly and the slag would hardly come off the seam. Things were not going any better...

We continued our experiments. We added fluor spar and feldspar to the rhodonite and the results immediately improved.

We now tackled arithmetic, trying to figure out what this seemingly cheap flux substitute would cost. In the laboratory everything appeared simple: we crushed the

pieces of stone with a hammer and after screening it we had ready-made flux.

"But how about mass production?" I tried to find out from Dyatlov.

We began to calculate.

"We have to restore the quarry, hire workers, find stone-crushers and other machinery, etc. But who will do it and who will finance it?"

It also turned out that the rhodonite flux had essential production defects.

We tried other types of unmelted flux—chamotte and brick flux. They were very simple to produce, but there was the possibility of a lot of trouble with it in work; besides, they produced low-quality seams.

The institute had no right to give up. We continued to get danger signals from other cities. Our plant was also running short of AH-1 flux.

I called the technologists of the institute again.

"We have worked out three new types of flux, but the situation remains critical. What we need is not recipes or reports with lists of their components, but a reliable, tested flux in sufficient quantities, at a cheap price and with a guarantee that the plants will be getting it uninterruptedly. We must not lose heart because of our failures. We must persistently continue our search, thinking of other possibilities. We cannot take too long with it. Have you any proposals?"

No proposals were forthcoming. I dismissed my staff asking them once more to "think hard."

Dyatlov was the first to find a way out of the situation. He proposed to compose a flux of local constituents on the basis of our first AH-1 black flux. We did our initial experimental work of melting the flux in the plant's metallurgical furnace, later continuing it in the institute laboratory, where we had a small electric furnace. We met with one failure after another, but Dyatlov

continued his efforts: he raised the temperature in the electric furnace and added coke to the charge. The coke produced an asphyxiating coal gas. We had to move the furnace elsewhere and provide better ventilation. Our search continued and, at last, in great pain, the improved AH-2 flux was born.

Though the flux met all the basic requirements, we were immediately confronted with another problem, which was practically insoluble at the time: how would the plants produce this flux?

The metallurgical electric furnaces were needed for steel smelting and could not be depended on. For real industrial production of flux every enterprise would have to build a capital electric furnace, which was more than most of the plants could do at the time. Our plant set up two small furnaces, fashioned after the laboratory model, and organized its own flux shop. We also produced some, but all in all it was but a drop in the bucket. Our plant issued the AH-2 flux only for welding especially important seams and, it goes without saying, we could not supply any other plants.

Thus, we developed a new flux, and the flux was not bad, but the industry had no flux anyway...

In those days I repeatedly recalled our pre-war attempts to utilize blast-furnace slags as a flux. This idea had always appealed to me; it was simple, cheap, accessible—there were plenty of slags. At the same time we found that only the slags of blast furnaces working on charcoal were suitable for this purpose because they were free of sulphur.

In the beginning of 1941 I asked Academician Bardin, our well-known metallurgist, to help us get some slag in one of such metallurgical plants in the Urals. Bardin readily agreed, and soon our institute received a parcel. We were totally puzzled by the very first

analyses: every sample of slag contained a great deal of sulphur. We could not make that out at all.

And only during the war, when we were in the Urals ourselves, did we find out that the plant, which had sent us the slag to Kiev, had two blast furnaces, one of which worked on charcoal and the other on anthracite, and that by mistake we had been sent the wrong slag.

We now happened to come back to the idea, we had given up, by a lucky chance.

On one of his rare off-days our instructor Korennoi was on his way home from his vegetable garden.

In the plant settlement, at the intersection of the railway and the highway, Korennoi stumbled upon a pile of building slag. The experienced eye of the welder immediately caught the resemblance of the slag to the AH-2 melted flux by its light-green colour and granulation. The instructor took some of the slag home.

The following day he decided to try his luck. Fearing ridicule Korennoi made up his mind to wait for the lunch hour, when there would be nobody in the shop. The instructor poured some of his mysterious slag on a steel plate and turned on the automaton. Lo and behold! The electric arc welded a good seam.

Beyond himself with joy Korennoi repeated the experiment. Luck again! He did not believe his own eyes.

Could this greenish sand possibly be our salvation?

Early the following morning Korennoi rushed in to see me.

"Did you ever, Comrade Paton! Only slag and it welds! I tried it yesterday, it worked."

I remembered our unsuccessful Kiev tests, but was no less happy than Korennoi. Maybe we had made too hasty a decision then?

"Go to Dyatlov and Slutskaya," I said to him, "they had tried many slags in Kiev. Be sure you check up on

the chemical composition of the seam metal and take some ground edges."

The very first analyses proved encouraging; the mechanical properties of the seam were also quite satisfactory. It gave us hope. I immediately asked my workers to go full steam ahead. We sent a lorry to the railway branch and had a heap of slag brought to our laboratory.

But could we rest content with only what we had got by chance? There were many plants in the Urals smelting steel on charcoal. We decided to make a list of these plants, thoroughly investigate them and in this manner get the slag, which might be the best substitute for the "real" flux.

I went to Sverdlovsk where I obtained the addresses of twelve plants and some information on them. But paper is only paper. To get a real idea we had to visit the plants ourselves, find out what ores the pig iron was melted from, the method they used for granulating the slag, etc.

It was not so easy to travel at that time, but our institute workers visited nearly all of the twelve plants enumerated in the list. For some reason or other we had to reject most of them. The plant in Asha, near Ufa, met our requirements best. Both its old furnaces worked on charcoal, the pig-iron was melted from excellent Bakal ores and the slag was granulated in water.

The new flux promised big advantages. The enormous and permanent reserves of slag in Asha, the simplicity of preparation, the possibility of doing without the construction of expensive electric furnaces—all meant that under war conditions the slag flux was to play an important part. Malishev, the People's Commissar of the Tank Industry, actively supported our undertaking.

We went about things resolutely. Taking authoritative

letters and our laboratory welding machine along our group went to Asha.

The people in Asha were quite surprised to learn that a scientific-research institute took an interest in the by-products of their furnaces.

"It seems our old lady in Asha is still good for something," the chief engineer of the plant jested. "You can take the slag free of charge; we'll even pay you for taking it away. Our yard is full of this stuff."

The chief engineer agreed to change slightly the composition of the charge and raise, as our technologists proposed, the percentage of manganese content in the slag. We concluded an agreement according to which the Asha plant engaged to supply flux to all the plants employing automatic welding. The People's Commissar of the Tank Industry helped the Asha people get enough manganese ore and charcoal.

Soon the People's Commissariat awarded prizes to a number of workers of the plant for the production of the new flux.

From then on this concentrated slag was called "Asha Flux" in all official documents. The new flux was intended primarily for armour welding. Hence the conclusion: its quality requires constant and vigilant control. A small group of our workers remained at the plant. The workers had a portable machine, and each lot of slag, prepared for shipment, was strictly tested for its welding qualities. Our representatives also saw to it that the slag was kept clean, that it was not polluted with clay and that it was shipped to the clients without delay.

At our own plant we taught the people to protect the slag flux unloaded at the shop entrance against pollution and explained to them that clay and dirt in the Asha slag inevitably led to pores in the seams and weakened the welded joints.

The plants were now getting the flux through a central

agency and in unlimited quantities. The danger the automata might stop was, finally, liquidated.

For some time one of the railway station-masters could not understand what good this "sand" was to anybody. To his mind it was good-for-nothing and he detained the trucks with the slag. This station-master was prevailed upon and soon trucks with the "Asha Flux" sped to every part of the country.

At the same time a group of our technologists, headed by Rabkin, developed a variety of slag flux suitable for welding low-carbon steel with low-carbon wire, which solved another problem since the "Asha Flux" could not serve this purpose.

For the sake of justice we must say that for armour welding the AH-2 flux was better than the Asha slag, and it was preferred by some people both at the institute and at the plant. But these people thought in terms of the "ideal" and did not take into consideration the actual conditions. They ignored the fact the plants were unable to organize mass production of the AH-2 flux, tried to intimidate us and to dissuade us from using the "Asha Flux." We did not heed them, improved the welding qualities of the slag and did all we could to prevent unpleasant surprises.

Many hundreds of kilometres of seams on Soviet tanks were welded with the slag of the Asha little "old lady."...

9. AFTER THE TESTS ON THE PROVING-GROUND

During the cold and rainy summer of 1942 I spent my few free evenings on my vegetable patch.

Turning over the Urals clay with my spade I thought of the wonderful fat soil in my country-home in Bucha, near Kiev. I had always been very fond of digging around in the garden and moulding up the trees, finding it to be the best form of recreation.

Work in the vegetable patch has now become a necessity and I took it very seriously. All of our institute workers had vegetable patches, but in the autumn I was judged the winner in the competition for the "best crop." My potatoes were a feast for the eyes, while those of some of our workers were no larger than nuts. This gave rise to a lot of jokes and ridicule, and the following year the "poor wretches" had to use a little more elbow-grease on their spades.

On a Sunday, preceding May Day, the blue automobile belonging to the plant drove up to our "potato and vegetable department" and hopping over the bumps stopped near my plot. Portnov, the superintendent of automatic welding at the plant, got out of the car and walked up to me.

"Comrade Paton, I congratulate you from the bottom of my heart," he said solemnly. "The Government has decorated you with the Order of the Red Star. We've just received the information."

I instantly forgot my potatoes and let go of my spade.

This was my second decoration. I had been decorated with the Order of the Red Banner of Labour before the war.

Noblesse oblige. How could I repay the Government? Only by working still harder in order to bring the day of victory closer.

I took stock once more of what we had done to introduce high-speed welding.

The shop was getting more and more welding machines, but the tank-production plan had also increased. The first welding successes turned the heads of some of our shop workers. I argued with them:

"We've only just begun. Our main work is still ahead. We could use our machines on many more seams."

The chief of the hull department complained time and again:

"We are short of skilled manual welders and this tells on the quality of the seams."

What happened the same summer revolutionized the thinking of the plant engineers.

A tank-hull was being tested on the proving-ground near the city. The seams on one of its sides had been welded in the old manner—manually; the seams on the other side and in the head were flux-welded by an automaton.

The tank was subjected to heavy gunfire from a short distance with both armour-piercing and demolition shells. The first hits into the manually-welded side caused considerable damage to the seam. The tank was then turned around and the second side, automatically welded, was fired on.

The fire was over open sights and from a negligible distance. Seven direct hits were made one after another...

Our seams held out. They proved stronger than the armour itself and continued firmly to join the armour plates mutilated by the fire. The seams in the head of the tank stood the fire test just as well, not one of them giving way under the squall of fire. Twelve hits made holes in the head, but failed to damage the seams.

High-speed automatic welding scored a perfect victory. The test under conditions similar to the hardest front-line situation confirmed the high quality of the work of the automata.

I took heart. We proved what we had always believed in. The results of the test should be convincing enough to anybody.

Taking the materials of the test along I went to see Skachkov, the Party organizer at our plant. After reading the conclusions of the commission, which had conducted the test, he said to me excitedly:

"I'm amazed and very happy. Look, it says here that

the seams welded by your automata are in every respect superior and that it is necessary to make extensive use of high-speed welding at all the plants of the tank industry. We have a trump-hand."

He realized automatic welding not only raised the production of tanks but also made them stronger and more reliable in battle. He couldn't help being excited.

Skachkov immediately called a meeting of Communists —the commanders of production. Before the meeting he instructed me:

"You make a brief report, Comrade Paton. Don't be ashamed to scold those who are content with the way things are and, as we say, rest on their laurels. Make concrete proposals. Don't be shy, because you are not a member of the Party and don't be soft on them," he added with a smile.

In my report I took his instructions into consideration.

All those, who were under fire at the meeting, "threw up their hands" right from the start. We all had the same interests and now, after the proving-ground tests, the people at the plant took a liking to automatic welding. The superintendent of the hull department was particularly impressed by the results of the test. We concluded an alliance right there and then.

"Pals?" asked Soibelman, the superintendent of the department.

"Pals!" I replied. "We'll do our share, all right."

"Let's meet tomorrow and work out a joint plan of action," he proposed.

The superintendent of the department was a man of strong will, stern and very exacting. The least failure to execute his orders was severely censured. In addition to other shops, he superintended two mechanical shops. At the conferences which this engineer called in his office, he harshly scolded those who had done wrong. He was, apparently, ashamed of strangers and therefore never

invited me to these conferences. He was also very stubborn, though, and did not readily agree to any innovations. But if he took a fancy to something, he would put it in practice with all the vigour which was inherent in him.

It was thus also this time. As soon as the superintendent of the department acquired full faith in automatic welding, he changed his attitude at once. We agreed jointly to produce and put in operation new machines, above all, high-speed automatic welding machines on the conveyer.

During August and September we put in operation 11 new high-speed welding machines, thus tripling the number of our working automata.

We divided our responsibilities as follows: the institute designed the machines, provided the welding and flux apparatus, did the electrical work and put the machinery in operation. By that time the institute shop had acquired a presentable and up-to-date appearance. The department supplied the carrying structures, the fixtures and the conductors.

Our workers laughed: "The roles have changed. All you hear in the shops nowadays is: couldn't the automata do this work, too? And won't you give us this? And won't you do that?. . ."

We had run short of instructors. Once again I checked up on the personnel of the institute and transferred to the shop all who were suited to it by their knowledge, character and ability to work not only with the head, but with the hands, as well. These were, in the first place, Voloshkevich, Gutman, Boris Paton, and then, Rabkin, Suprun and Medovar. The additional mobilization of the "inner human resources" made itself felt in the shops at once.

The plant needed dozens of automatic welders. Men and women of different occupations, ages and back-

grounds came to the plant in those years. They all wanted to serve their motherland as best they could.

The automatic welders also differed. Among them there were: a student of a theatrical college, a rural teacher of mathematics, a collective-farm shepherd from Daghestan, a cotton grower from Bukhara, an artist from a Ukrainian city, occupied by the Germans. Next to his machine the artist always kept a pot of paint and having welded the seam in the head of the tank he wrote on the armour:

"Soviet soldiers! Destroy the enemies. Drive them out of our Soviet Land!"

"Westward, tank-heroes!"

Most of the automatic welders hired were 16-18-year-old boys and girls who had come from all over the country.

The tank turrets were welded by girls from the Mari Autonomous Republic. I remember when they had first come to the shop. They were brought in by the foreman who showed them around and explained to them the machinery and what we were doing there. The girls pressed close to each other, stared frightened at the cranes, which carried the enormous tank-hulls over their heads, and stopped up their ears from the din in the shop. I saw tears in the eyes of one of them. It was the first time they had come to such a plant, and they were thoroughly scared.

Several girls were sent to Sophia Ostrovskaya. In the beginning they were afraid of everything and adjusted themselves to the shop very slowly. Turning on the automaton, they screwed up their eyes and jerked their hands back; as the arc flashed on, they buried their faces in their hands.

At first they could not weld more than two rear ends per shift. But Ostrovskaya taught them patiently and persistently; soon her wards changed beyond recognition

and began to work independently. One day Ostrovskaya went to see the girls, who proudly said to their first instructor:

"We are now welding eight rear ends per shift."

They worked conscientiously and carefully followed the instructions of the foremen.

The automatic welding of the sides was done by girls from Kursk Region. Very lively, clever and resourceful, they easily adapted themselves and always laughed and sang a lot. They brought brooms and brushes and kept their working places very tidy. Failure to fulfil the plan they considered the greatest misfortune, though this happened rarely.

As a rule these remarkable girls would hang a ribbon or a picture, cut out of a magazine, somewhere on the automaton where outsiders could not see them. Youth always tells...

The boys worked mainly on welding head units, and on the conveyer. There were many boys from the Ukraine; the war made them grow up overnight. They approached the automata with an air of adults, at once found that they resembed some other machine they knew, infallibly made "rationalization proposals" and even found things to criticize. They were uncommonly proud of their speciality and looked down on the old and experienced manual welders:

"We have machines and what have you got?"

Some of these countrymen of ours were of very small stature. To reach the control panel they had to climb on a box. They found it very hard at first, but they were courageous and proud, they did not want to lag behind their fathers, who were also working at our plant, and were particularly stubborn. They finally prevailed and were given independent work on welding motor casing. They always considerably overfulfilled their assignments. Many of the boys became adjusters within six-ten months,

and one of them even became foreman of his shift. Among these young people, who treated their work with the seriousness of adults and the enthusiasm of youths, pupils of industrial schools were especially notable for their knowledge, discipline and exemplary behaviour.

Our instructors were very fond of the young people and the latter paid them in kind. This friendship yielded important results—the half-childish hands coped very well with the production of redoubtable arms for our Red Army. This was possible only because of the automatic machinery.

10. SENSE OF RESPONSIBILITY

In his family, in his home and personal life, in the relations with his friends a man can be gentle, amenable and tolerant of the weaknesses of other people. It is quite different at work. Where he is responsible for things, entrusted to him by the people, the above-mentioned traits may frequently prove a disadvantage. This applies in double measure to a leader. The ability to exact compliance and to see the work through to the end is a very important quality.

But let us first agree on what we mean by that.

I don't believe any orders or demands of a leader carry the real moral force if he does not apply them to himself. No one should ever have any reason for thinking: "You demand that I do it, but what about yourself?"

In the Urals I asked my co-workers to spare no efforts. The oldest of them were nearly half my age, but I never made any allowances for my age or health. Rain or shine, I came to the shop at exactly 9 in the morning and infallibly went first to the shop, rather than to the laboratory or to my office. I stayed in the same room with the other

workers and, though this was caused by a shortage of premises, the constant contact had its merits—it helped us stick together in those hard days. True, we all spent very little time in the office. I did not allow anyone to stay there too long.

I took part in the assembly and adjustment of every welding machine. I carefully watched them until the initial period of difficulties was over. I seldom appeared where everything ran smoothly, but went regularly to wherever there were difficulties or possibilities of lagging.

I never waited to be told that "everything was in order." When some new innovation was tested on our automata, I used to go to the shop without the "author." This gave me the opportunity to hear the frank opinion of the plant workers.

At that time the institute had no assistant-director, nor any scientific secretary, nor yet any chief of the "New method department." I had to supervise the elaboration of new themes, plan the work, conduct an extensive correspondence with plants and People's Commissariats, manage the laboratory, the shops, the instructors in the shops, etc., all by myself.

Despite all this work, I never allowed myself to shift the responsibility to someone else, but having assigned anything to anybody, I always watched the execution of the assignment in every detail without missing a single trifle.

One day one of my young co-workers jestingly reproached me with estimating the efficiency of my pupils by my own efficiency. That did not seem to suit them very much.

I answered him:

"The efficiency of man depends on his feeling of responsibility. Get the full measure of your responsibility into your head, and you'll see what big things you can do."

I never worked out any methods of educating people. My ideas and ways had, apparently, formed themselves during the long decades of my work with young people. I always strove to train them in the spirit of responsibility without which one cannot really love his work.

I remember the following incident. I came to the shop together with the superintendent of the hull department during the lunch hour. One of our instructors was working on one of the first machines for welding sides. The work had not yet been completely mastered. At the moment the instructor was in the dining-room, but near the machine I saw some bustling people and heard nervous voices.

I felt there was something wrong there and rushed to the machine. The machine was belching billows of smoke. The plant electrician was at a complete loss and did not know what to do.

I was told the instructor went to lunch and gave the plant foreman permission to run the machine in his absence; the latter made a mess of it.

The guilty instructor was now running across the shop to the automaton. In an instant he jerked the switch on the panel and turned off the current. The motor was saved; the only thing that had burned was the varnish on it.

The instructor turned to me, wiped his moist forehead and tried to find in my eyes approval of his actions.

"I am censuring you for neglect of your duties, for leaving a running machine without supervision."

He was literally dumbfounded. I realized he felt hurt at the moment and probably considered me an unfair and irascible person. But I was sure, nonetheless, I had acted right.

The instructor was biting his lips. In this man I valued his practical grasp of things and his ability to

work in the shop. And precisely because of that I could not overlook his unwarranted action.

Several days later this man and I were coming back from a plant Party Committee meeting where we had been given encouragement. I was in a good mood, and the instructor felt it. Aware that I did not like any beating about the bush, he came right to the point:

"I want you to do me a favour, Comrade Paton. I've been working a long time with you and have never incurred any penalty, but a few days ago you... Well, don't record it if you can."

"No, my good fellow, I can't. Let's talk about something else."

"But I got you right away and realized I was wrong. Besides, I'm no child, and I prevented the breakdown myself."

"Yet you might easily have caused it. Don't ask me for it. You are doing good work now, but I can't help it."

The instructor hung his head and silently walked beside me on the planked footway.

"You'll thank me for this reprimand yet."

On my solicitation some 18 months later this instructor, together with some other workers of the institute, was decorated with the Order "Badge of Honour."

Let me tell you another episode. It happened when the institute had only just begun working at the tank plant. At that time our automata were doing only one thing—welding sides. This work came to an end, because there was a shortage of armour. The two machines that until then had worked full time (three shifts) were now on "hunger rations." This could have easily made the workers of the institute lose confidence. I was sure the plant would soon get the requisite quantities of armour. It was very important that all of our comrades feel the same way. Explanations alone would not do.

One day, as I came to see one of our workers who was

engaged in welding sides, I saw the machines were not working.

"Why aren't you doing anything?"

"There's no armour."

"And what have you done to get it?"

"I asked for it in the shop and tried to get it from the administration."

I raised my voice:

"You haven't tried hard enough. You don't have to complain but fight for it, see that you get it rather than the manual welders. You've, probably, just been sitting around waiting. . ."

The instructor knew he could not help it and answered calmly:

"There's no armour at the plant."

But I would not give up:

"If there isn't any today there will be tomorrow. You are not taking enough interest; you are not looking ahead; you are only living for the moment. That won't do!"

I exaggerated it, of course, and did it purposely. I was almost certain the instructor would now lose his peace of mind.

To be sure, the superintendent of the department told me the same evening this instructor had seen him, had reproduced our high words, insistently demanded armour for his section and would not take any excuses.

Several days later this instructor and I met again.

"There's no armour yet," he uttered cheerlessly.

"If you don't have any today, you'll have it tomorrow. Tell me what you're doing to be ready for it when it comes," I said to him.

"What am I doing to be ready?" he repeated puzzled.

"Certainly. When the armour comes, you'll begin putting your machinery in order, checking up on the schemes? Look here, we'll soon have more than enough armour

and is that when we'll start adjusting everything? If our machinery does not run then, we'll never outlive our shame."

The instructor's face brightened up. At that moment he, apparently, understood what I wanted him to do all along. He replied very briefly:

"Yes, we must be getting ready right now. May I go to it?"

I must say, this instructor did very conscientiously all he had to do. I doubt I should ever have achieved the same results by merely issuing an order.

If you want to inculcate a sense of responsibility, you must begin with trifles, with day-to-day control. I remember sending the following note to one of our junior scientific workers:

"See if you can't think of a system of payment for the welders on the conveyer in order to get them interested in automatic welding."

I had decided to pay the welders, who were operating the automata on the conveyer, something like a bonus from the institute and wanted my co-worker to take part in elaborating this idea.

I recalled that before the war he had participated in the first experiments of welding corner seams, and now I wanted him to work out methods of welding these seams on the production line. The idea of corner seams now haunted the instructor day and night and, sticking my note into one of his pockets, he simply forgot about it. He, probably, reasoned thus: "It'll be more than a couple of days before anything happens, meanwhile I have more urgent and important things on my mind."

But I did not forget my note and three days later went to the conveyer. When the instructor saw me, he, apparently, immediately thought of his "little debt" and in order to get me off the subject began hastily and with

exaggerated animation to praise "one interesting device, which we have decided to use today..."

I listened to him patiently, approved the device and then told him what I had come to see him for:

"How about your proposals now?"

My co-worker resorted to a ruse:

"What proposals?"

"Come, come now, my good fellow. Your proposals for paying the welders."

The instructor blushed deeply and never even tried to make any excuses. Since then he had never let me down or been careless.

The ability to exact obedience, of which I am speaking, must in no way make the leader callous or dry, or engender in him a stereotyped approach to man. There are as many characters as there are people. The better you learn their particular traits and inclinations, the easier it is to work with them. Besides, the psychological state of each person may change from day to day, which means he requires a different approach each time. If you do not constantly take this into consideration, your strict and exacting attitude may produce only negative results.

One of our collaborators, who worked in the shop, had reached the stage of extreme exhaustion, and his nerves gave out completely. In addition, he had met with an accident.

One day he was working in a tank-hull and did not notice a spark drop on the cotton-waste he had in his overalls' pocket. Soiled in oil and gasoline the cotton-waste blazed up and within a few seconds the overalls had caught fire. Fortunately, it all turned out all right, but to the instructor that was, apparently, the last straw that broke the camel's back.

Several days later a conference was held in my office. I offered the instructor in question a certain assignment. He got up and said curtly:

"I won't work there any more. I can't."

"And who is going to instruct the workers there?" I asked him calmly.

"I don't care," he answered harshly. "Anybody but I."

All members of the conference stared at him in amazement. To turn down an assignment and do it so defiantly was, in our midst, an unprecedented incident. Everybody, obviously, expected me to storm and rage. But I only looked at him intently and, without saying a word, turned to the others:

"Let's move to the next question, comrades."

The hero of this episode sat till the end of the meeting silent and frowning.

In the evening he came to see me. His cheeks were ablaze.

"Comrade Paton, excuse me if you can and forget what I did. I'm tired. It's my nerves."

I rose swiftly and made a few steps towards the instructor.

"There, there... I've already forgotten. Anything is likely to happen in work. Go ahead, keep on working and I wish you luck."

I hastily sent this man away to preclude all further apologies and to save him the awkward feeling which is inevitably connected with them.

At the conference I, certainly, could have easily broken this man's resistance without taking his psychological state into consideration. But who knows, I might, simultaneously, have destroyed something very important in his soul and have gravely injured the man.

My idea of the sense of responsibility is not merely industry and conscientiousness. These qualities are very valuable in themselves, but it seems to me the scientists, who strive to train their students in the ability only to carry out well other people's ideas, rather than to become independent, active and creative research workers, are

wrong. Such scientists can frequently work very well themselves, but around them there is a void.

Every scientific institution is duty-bound to "create people." The scientific-research institute, which lives only by the name of its director, or by its scientific reputation alone, isn't worth a tinker's damn.

We must develop and strengthen in our young people a faith in themselves, in their powers and abilities. This is, certainly, no simple matter. We must train and educate in our own characters persistence and perseverance. We must not fear hard work, risk or the first failures. In most cases defeat means only lack of will.

It is sometimes necessary to make a person fight himself, fight his own inertness or momentary weakness, and change his old ideas of what is and what is not possible. The person may feel he has already tried everything, experienced everything, and it is important to encourage him at this critical moment and open new prospects before him.

In the different chapters of these recollections I have cited many examples which confirm the correctness of my ideas.

We very rarely managed to find the right solution for the problem on hand immediately, at the first stroke.

The first version is usually what comes to the head first, at once; it is what lies on the surface. As a rule I asked my workers to hand in several versions.

It sometimes happened that in elaborating a new design of a machine or mechanism we found one particular thing, one detail in the rejected version that we liked. This served to move our thinking in the right direction and our thoughts extended and developed...

I've already told the reader how our designers worked during the war. The very profession of a designer keeps him constantly on the look-out, though this does not always work out in practice. Deprived of a creative vein,

the designer sometimes merely rehashes the old, makes a compilation or only small improvements.

We rejected this course. Our designers learned to think in terms of great problems and soon convinced themselves this was much more interesting. But for this it is necessary to go courageously through all mistakes and disappointments, not to do anything halfway and to see the thing through to the end.

Take, for example, the following case. I give one of my designers an assignment which he thinks is beyond his ability, even unreal.

"Nothing will come of this... It can't be done," he says.

It's clear, the unusual commission scared the man and he hasn't thought it through. He leaves me with a vague and heavy feeling he was given a burdensome task.

In due time we examine the drawings or even the first model.

The designer himself thinks very little of his brain-child:

"I haven't got it; the thing is very awkward. It is a long way from the original conception and it will hardly ever come closer to it..."

Deep in his heart he is hoping we might turn his work down and give him a chance to do something within his power. But we relentlessly shatter his "dreams"; severely, cruelly we criticize him, make all possible suggestions and ... demand a new version.

Time goes on. After the third or fourth version, after heartaches and chagrin, the mood of our designer takes a sharp turn. His dull looks disappear; there are bellicose sparks in his eyes; he now fights temperamentally for his solution, argues with us and demands that his design be tested on experimental samples.

Everything is in order now. The man is enthused, he's got a taste for the thing now; the assignment is no longer a mere "whim" of the director, but has become his

own personal affair, near and dear to his heart, and that's what I've been after.

Success at last! The mechanism has been created, tested in the shop and it has shown itself good in work. The shop began to manufacture it serially.

The designer is elated; he keeps telling his comrades:

"What did I tell you? See? It worked out! And you criticized me and picked on me. . ."

He has already forgotten how he came to see me (more than once) during the first days and tried to talk me out of the order and make me write to the plant that it was easy to think of all sorts of intricate things for welding, but it was quite different to design machinery for them.

Of course, I never reminded him of his requests.

Before the war it had been believed that corner seams of T- and lap-joints could be welded only in the "little boat" position, i.e., with the electrode in the vertical position. I insisted that our technologists learn to weld the seams without the "little boat" and that they work out the technology of this type of welding for the industry. The technologists dragged this thing out, considering it a trifle and wondering why I was "interested in a question of secondary importance."

And only now, when they came face to face with production, did they realize their mistake. An enormous and heavy tank-hull lay on the conveyer-truck and it was impossible to turn it into a position handy for the automaton. It was much simpler for the manual welder, for he could take any position he wanted, while all sorts of trouble occurred in automatic welding—the liquid metal leaked out, the seam formed unevenly, etc.

What could we do? Design cumbrous fixtures for turning the heavy tank-hulls? No, we could not afford that.

I no longer had to persuade our people how important the work was, which they had so long neglected. Our technologists were stubbornly searching for a solution of

the problem; they began to use multi-layer welding, a special flux, which helped the seam to form right, etc. The creation of a copying device—a device, which directed the electrode along the caulking of the seam—now acquired special importance. It was a hard problem as regards both the design and the technology and I assigned it to one of our young, but competent and persistent workers.

He lost heart many a time, despaired and was ready to give up. We often had to encourage and inspire him. We tried many versions, repeatedly changed our approach to it and, finally, succeeded. The copying device turned out good and the automaton now welded the corner seams with a slanting electrode and with the hull in a horizontal position. Thousands of tanks were welded in this manner. Our technologists, including the designer of the copying device, realized that if you put your heart and soul into something you don't have to fear any difficulties.

At the end of 1943 the Government decorated a large group of scientific workers of our institute with medals and Orders. Many of our workers were entered in the honour roll of our plant and many more were mentioned in the order of the People's Commissar of the Tank Industry. They included those of whom I spoke in this chapter.

The appreciation of our services showed that our young scientists had been able to educate themselves in a high sense of responsibility to our motherland. We never wanted to advertise ourselves, to boast of our work or to show ourselves as "good fellows." The generous Government award was received by our young people and by all of us as a direct appeal for even more devoted and more selfless work in the name of victory over the enemy.

11. WAY TO SIMPLICITY

Under pressure of life we completed the first stage in modernizing and simplifying our automatic welding machinery in the middle of 1942. However, the "brain" of the automaton—its welding head—remained complicated both in operation and manufacture.

Our pre-war experience had not been very significant. Working at the plant we now actually saw the shortcomings of our two-motor head. It proved not only complicated, but also insufficiently reliable.

At some other time we might have tolerated it longer, but the war spurred us on.

The small reserve of old heads, we and the plants had, was coming to an end. We could not even think of manufacturing intricate mechanisms for them in our shop. The attempt to organize their production at special plants during the war proved to no avail. It was necessary to alter the design of the head, make it more reliable in work and easy to manufacture by simple means.

The length of the arc was regulated in our head automatically by means of a two-motor differential mechanism. Until that time the automatic regulation of the arc length was considered a great advantage.

In 1942, Vladimir Dyatlov discovered the phenomenon of self-regulation of the welding arc and proposed an absolutely new and original type of head for flux-welding. The balance of energy in the arc changes depending on its length. On the basis of this Dyatlov proposed to feed the electrode wire in the zone of the welding arc at a constant rate corresponding to the given regime of welding.

Dyatlov based himself on the following theses: If the arc lengthens under the influence of an outside factor the rate at which the wire melts will diminish. The rate of wire feeding will become greater than the rate of its melting, as a result of which the arc will become as short

as it was formerly. On the contrary, if the arc becomes shorter the rate of wire melting will increase and the rate of wire feeding will become smaller than the rate of its melting, while the arc will lengthen.

But this bold idea needed testing. We made tests, during which we artificially put various obstacles in the way of the head. The tests showed that the arc regulated itself under strong currents of 800-1,000 amperes.

This discovery enabled us radically to simplify both the electric scheme of the head and the wire-feeding mechanism. We no longer had to regulate automatically the arc length for it was enough to have a simple mechanism for revolving the rollers, which fed the electrode wire. Nor did we need the second motor, i.e., the direct-current engine and its feeding scheme. The whole electrical and mechanical part of the head were greatly simplified.

Dyatlov's idea disconcerted a good many people at the institute. Objections and protests poured in from all quarters. Everybody thought the very foundations were being undermined and flux-welding was in imminent peril. In the beginning I was probably the only one who supported Dyatlov firmly and without any reservations.

Some people were saying:

"How come? We've worked on our head for so many years, defended the principle it was based on and now we're suddenly going to give it up? Why, this is a complete break!"

"Yes, it is a break, and a very abrupt break at that," I answered the critics. "But what of it? What is it you're so afraid of? Why must we persist and hang on to the old only because it has already been tested while the new is yet unknown? Not so long ago we didn't even have any automatic flux-welding. Let's make a model of the new head, test it and then see who is right."

"You'll see the head won't work well. As soon as there

are fluctuations of tension in the circuit all the regimes we have worked out will go overboard."

"We shall see," I replied calmly to all these prophecies.

We needed a man who would be fascinated by the new and daring idea and would find a successful constructive solution of the problem. Sevbo was just the man. He had always worried about the fact that our old head was too complicated, that it had many vulnerable points and was frequently put out of commission. Designing the heads at the institute before the war was the monopoly of one person. He considered them his personal jurisdiction and did not let any other technologists or designers have anything to do with them. This was, of course, wrong and it impeded progress.

Now Sevbo started working on the design. In addition to the feeling of dissatisfaction he had a clear guiding idea. It is always easier to design a complicated machine than a simple one, which would answer the same purpose. The constant and main difficulty of a machine designer is to attain simplicity. Dyatlov had paved the way to it and Sevbo gave it a constructive solution and designed a new welding head.

The new head passed the long and strict laboratory tests with honours. The hardest conditions, which it might encounter in production, had been set up. The head went confidently through all the "traps" laid for it and by its entire behaviour proved its right to life. There were also some shortcomings, of course, but Sevbo quickly eliminated them.

Soon the first simplified one-motor heads left our shop.

There were some who thought we had better not hurry handing them over to the plant.

"Why rush? It's a risk anyway. If we hinder the plan we won't be the better off for it."

"There'll be no trouble. I believe our simplified heads will justify themselves in the shops," I answered invari-

ably. "You say there's a risk? I think it's negligible. But if the head works it will immediately win recognition and we will be able to boost it in our plant and in all the others."

I stuck firmly to my point of view.

We asked Portnov to instal the first head on one of the machines for welding sides. The superintendent of automatic welding was wont to grumble sometimes: "The institute has experimented long enough on the machinery in my charge. A plant shop is no research laboratory."

But all this was said for the sake of appearance. Portnov himself was anxious to get simple and reliable heads. Besides, we were on good terms and he knew that, in the hour of need, if some machine went haywire or if we started getting uneven seams, the institute would be there to help with word and deed.

The shop people were frightened at first:

"Alterations again? But that means stopping the machinery for some days! What about the programme?"

We asked for only 24 hours. Our men worked day and night. We did everything ourselves, and in the morning the machine was ready. During the first days our instructors watched it without a let-up. The new head worked well and steadily maintained the welding regime. All the welder had to do to control it was to push several buttons on the panel.

All fears of the sceptics were fully dispelled, and we heard no more criticism.

The new head was tried for the first time in November, 1942, but towards the end of the war it had welded hundreds of kilometres of seams on the sides of tanks. Beginning with January of the following year we installed on all new machines only the simplified one-motor heads manufactured in the institute shop. They soon won over every war plant and played a big part in the production

for the front. This was the turning point in the spread of high-speed welding in the country's war industry.

Production experience proved that the principle of feeding the electrode wire at a constant rate was wholly reliable. Developed during the war this principle has been preserved in the new welding machinery of the institute to date.

Self-propelled welding heads were another achievement of our designers. Their principal idea was that the motor, which fed the wire, was simultaneously used for moving the head along a special rail-track. The self-propelled heads were of particular advantage in that they did away with the complicated carrying structures or trucks.

The substitution of one principle of building the welding head by another, which was simpler and more reliable, offered the designers new opportunities. This is one of the main reasons that the years of the Great Patriotic War proved so fruitful in the history of the development of automatic welding in our country.

12. WITH OPEN EYES

Whatever we did, whatever problems we were trying to solve, the quality of the seams was always our main concern. A good deal had already been done in that direction. In the middle of 1943 we attacked a new serious theoretical problem.

We knew the main features of the process taking place in flux-welding, but did not have a deep enough insight into its essence. In elaborating the technology of welding and choosing the regimes we often had to grope in the dark and therefore conduct additional experiments.

Life itself impelled us to take up a serious research problem.

Under plant conditions changes of the tension in the circuit affect the work of the welding heads. During the war this was particularly disappointing. Normal work of the machines was disrupted, the seams showed defects—they were either insufficiently welded or burned, or lacked uniformity. The quality of welding noticeably deteriorated.

In order to find efficient means for fighting this evil we had to determine, first of all, to what extent and under what circumstances the fluctuations in the plant's circuit were harmful and how they could be neutralized. I also considered it very important that we analyze the work of different welding heads under these conditions. And though the institute did not have even the minimum facilities for this research, we decided we had no right to postpone it till "better times."

This job was tackled by two young scientific workers—Boris Paton and Arseny Makara. They immediately clashed with the theory, at one time advanced by American welders, who believed that the thermal energy, required to melt the electrode and the metal, was formed while the welding current was passing through the melted slag.

There was also another opinion. Its adherents considered flux-welding a combined process. They thought the electrode wire and the welded metal were melted both by the energy of the arc and the thermal energy produced by the current passing through the slag.

The first theory was rejected by Soviet investigators, while the second one had adherents as well as opponents. We questioned the theory very much, but we could only prove we were right by carefully conducted and checked experiments.

Meanwhile our young scientists did not even have the requisite instruments. In the winter of 1943, there was a travelling laboratory in a carriage at the station, and Boris and Makara succeeded in borrowing its oscillograph for a day, bringing it in a sled to the institute laboratory.

We thus obtained oscillogrammes, which shed the first light on the nature of the process taking place under the flux. Soon we acquired another, more perfect, oscillograph, and with its aid continued our research.

Even for this big and complicated work I was unable to release the two workers from their primary duties in the shops. They had to snatch a little time before or after shifts, either in the morning or in the evening, and frequently forego sleep. Leaving the shop they took the oscillogrammes along and analyzed them at home, later doing experimental welding in the laboratory.

The young investigators had a hard time of it. But they also had one advantage: they could check on all their conjectures or doubts in the laboratory and right in the shop under the exacting production conditions, as well.

Dozens of experiments were conducted; the screen and photographic prints recorded numerous oscillographic curves.

It was proved beyond a shadow of doubt that the process taking place under the layer of flux, when welding in the lower position, was purely an arc process, that the arc burned in a gas-bubble of melted flux. The flux itself hardly participated electrically in the process, its role was confined to the protection of the melted metal and its alloying, as well as to increasing the stability of the arc. The essence of the process of flux-welding was thus clearly understood for the first time.

Our investigators discovered the principal laws governing seam formation and thus made it possible to elaborate regimes of flux-welding on a scientific basis.

We could now do our practical work with our eyes open and strive for high-quality seams more actively and consciously.

Boris Paton and Arseny Makara analyzed in great detail the work of different welding heads under the conditions of fluctuating tension in the circuit, and recom-

mended to industry concrete methods of fighting these harmful phenomena. The young scientists published the results of their work in the beginning of 1944, in a special book, which evoked great interest among the welders. The basic conclusions of the research are true and valid to date.

13. AT FIFTY-TWO PLANTS

Automatic welding was winning over more and more plants. We were receiving requests to send them guiding materials and to help them with apparatus. Many people learned about the new welding method from newspaper articles. I remember that after Academician Y. Yaroslavsky's article in the *Pravda*, in which he had praised automatic welding at a Urals plant, we were showered with letters from plant directors, engineers and welders.

We realized at once they all made different approaches to the matter.

Thus, for example, the engineers of the Omsk Locomotive Works acted vigorously. They obtained our drawings, manufactured the apparatus after these drawings and, having gone through all the "infantile disorders" of the new method, firmly got on their feet.

Others only obeyed the orders "from above," worked half-heartedly, engaged in a long-drawn-out correspondence with us and for months on end "pickled" the apparatus we had sent them. They waited for the institute to hand them ready-made automatic welding on a "silver platter."

The attitude of the plants to the use of high-speed welding depended first of all on the ability and willingness of their leaders to look ahead and to live not only for the day, but also for the future. I shall show later what automatic welding gave the far-seeing people. But there were also would-be leaders who did not care to burden

E. Paton with sons Vladimir and Boris

themselves with additional cares. Mechanized welding is less flexible than manual welding and requires high industrial skill. It was this that scared the lovers of a quiet life.

But sooner or later we were able to establish businesslike relations with most of the plants. This was, apparently, due to the fact that the institute readily took upon itself the greater part of the work.

Our instructors always had the first word. The plants sent to the institute the working drawings of the objects being transferred to automatic welding. These were often new types of machines or arms and ammunition which seriously complicated the task of the designers. To make the working design of a welding machine usually required one to two months, but sometimes we had to shorten this period considerably. One day we received the request of a large war plant for a design of a machine for welding an important newly introduced unit in the tank, and within twelve days the plant had all the drawings on hand.

Well, suppose we made the drawings, sent them to the plant and received a reply. Could we say we have done our part and that was all there was to it?

Our very first experience showed us that to act in this manner was to stop halfway.

In most cases we ourselves had to supply the plants with welding, flux and electrical apparatus. Should a scientific-research institute make it its business to produce them, especially under the conditions we found ourselves?

Formally, certainly not. Nobody had any right to demand it of us.

But we kept receiving orders and our electro-mechanical shop filled them. Everything should have been easier and simpler if we had produced the apparatus in big series, but that could not be done, since the apparatus was constantly improved. The institute incurred these "troubles" itself and hence could not complain...

We furnished the apparatus and the plants manufactured the machines after our drawings. But that was not all by a long shot. Where were the plants to get the people who knew high-speed welding and were able to assemble, adjust and put the machine in operation? Our instructors had to be these people. They lived a hard and unsettled life, frequently spending more time travelling than at home. Our "nomads"—Oleinik, Radchenko, Ostrovskaya, Voloshkevich, Kazimirov, Korennoi, Medovar, Rabkin, and others hardly ever returned from a trip without immediately getting a new assignment and being off again.

We usually timed the arrival of the instructor at the plant to the completion of assembly, but soon found out that, left to their own devices, the plants dragged things out too long, and we tried to send our people there in the beginning of the assembly. Under these circumstances the instructor temporarily assumed the functions of superintendent of automatic welding, i.e., numerous troublesome responsibilities. This was a great burden, but it justified itself.

The behaviour of our comrades deserved the highest appraisal.

It was hard travelling at the time. Besides, our people often had to take along heads, parts of the equipment and spare parts. It happened that in urgent and unexpected departures our instructors could not get a railway ticket and had to make themselves comfortable on a footboard or buffer and only later get with their heavy luggage into an overcrowded carriage. Resourceful people managed to outwit even the meticulous guards and always had keys to open the carriage doors. It was no fun travelling on a footboard in a 30° below...

Our people had to live for a long time, sometimes for months on end, away from their families, eat anything they could get and when they could get it, sleep in over-

crowded dormitories, stay in shops for days running and independently solve complicated problems away from the institute. But I do not remember a single case not only of anybody turning down a difficult assignment, but even of trying to avoid it for valid reasons. Once the instructor got an assignment he set out on his trip without any further ado.

One day Makara had to go to a distant plant, but suddenly fell ill. I sent for Medovar, a junior scientific worker. Medovar was a dependable man. At the front, whence we recalled him through the State Defence Committee, he had received some good schooling.

"I want your advice," I said to Medovar, who had but shortly before returned from a long trip. "Makara has to go to Siberia but, as you probably know, he has fallen seriously ill. What shall we do? Whom shall we send? Here is a list of names; let's think it over together."

We looked through the list. For various reasons we rejected one candidate after another. One was needed in the shop, another one had just come back from some plant, still another was away at the moment.

Boris Medovar smiled:

"It seems I'll have to go, Comrade Paton. There's no one else."

I protested but not very sincerely.

Medovar heard out my objections and went to get his documents. I think he divined my simple "diplomatic" method.

I won't be wrong if I say that each and every one of our young workers would have done the same. Business always came first.

Hard as these trips were, they always afforded great moral satisfaction and frequently useful experience.

I remember one of my trips to a plant where I spent three days. Korennoi, Sevbo and Rayevsky were already working there. We were in the office of the plant's chief

engineer and our business talk lasted till one o'clock in the morning. As I was about to leave I was told the workers wanted me to come and see them. They wished to make my acquaintance and have a little chat with me...

I stayed in the shop until 4 o'clock in the morning and never regretted it. I was surrounded by welders, foremen and adjusters. They not only asked questions, but also offered advice and suggested ideas which I doubt would have ever occurred to me. I was not ashamed to question them and ask for explanations, because these men had extensive practical knowledge. Even if the suggestion is made in very general terms or even primitively, even if it has not been thought through to the end, it still has a valuable kernel which can be developed, "worked up." Such promptings should never be disregarded. On the contrary, one must encourage the people to talk and must be able to listen to them.

We received many letters from directors of plants and leaders of Party organizations with an appraisal of the role of high-speed welding.

The technical director of a certain plant reported that the transfer of war matériel from manual to automatic welding made it possible to release one-third of the welding personnel, to economize a lot of electrode wire and electric power and to fulfil the production plan, all because the institute had sent them welding heads and drawings of the welding machinery.

The following figures are quite instructive:

At the end of 1941 there were only three automatic welding machines operating at the country's plants, at the end of 1942 there were 40 of them, at the end of 1943—80, in March 1944—99, and in December 1944—133. By that time we were working at 52 plants.

Our work at industrial enterprises gave us considerable experience, but it was not collected or systematized. The

first and second editions of my book *High-Speed Welding Under a Layer of Flux* were pretty much outdated and needed substantial revision. In March 1942, I sent my manuscript to the Sverdlovsk publishing house for a new publication.

I had worked on it in the evenings since the end of 1941, but somehow could not finish it. I was writing it "hot on the scent of life"; practice advanced ever new problems for which we found solutions, and I wanted them reflected in the book.

The publishers took too long putting the book out and meantime some of its chapters were again outdated. While they were procrastinating we had created the slag-flux and considerably simplified the welding apparatus. We could not do without all this in the book. I had a good deal of struggle with the publishers before they agreed to include the additional chapters. And still, at the time the book came out—in November 1942,—it lagged behind life in a good many respects.

I did not know whether I should be happy or sad about it.

A technical book, however remarkable, is only a book, and cannot take the place of personal contacts among people working in the same field of science or industry. Meanwhile each plant introduced automatic welding in its own way, guided by its own ideas of it. I thought it useful to call a conference at which we might generalize our experience and work out a common platform.

The People's Commissar of the Tank Industry fully supported our initiative. In his order he noted that production practice confirmed that automatic flux-welding was in many respects superior to manual welding. The order made special mention of the high quality and strength of the seams demonstrated at the proving-ground tests. The People's Commissar also observed that despite these

achievements automatic welding was not, as yet, being properly developed and made use of at all plants, and proposed "to call a conference of the most competent specialists in the field of automatic welding."

The conference, which took place at our plant at the end of January, 1943, was attended by representatives of many plants and organizations. The sittings were stormy; a real struggle flared up around certain issues and feelings ran particularly high at the sub-commission on apparatus.

We zealously fought for our simplified head, which had been tested in production and found efficient. The representatives of a certain electrotechnical plant defended their model and attacked the principle of constant feed-rate, which we had accepted. Their head was more complicated than ours and the reliability of its scheme of regulation and some of its units were under question. But the representatives of the plant tried to assure the conference the scheme was flawless.

As a matter of fact this was no discussion as to whose head was better. It was a conflict between two different approaches to the problem.

The people from the plant tested their head in the laboratory and did not know how it behaved under the trying conditions of production. They also failed to take into consideration the great hardships in manufacturing the complex welding heads in war-time. We felt theirs was an academic, a "laboratory" approach, while our position was wholly determined by the requirements of life, by our long work at plants.

The conference adopted an "appeasing" decision: to recommend the introduction of both head models. However, life reconsidered this elusive decision and passed its own verdict. Most of the plants introduced our heads with the constant feed-rate.

14. HIGH AWARD

In January, 1943, I was one of the plant workers decorated by the Soviet Government with the Order of Lenin. The Decree of the Presidium of the Supreme Soviet of the U.S.S.R. read: "for the exemplary fulfilment of the Government's assignment to increase production of tanks and armoured hulls."...

Six months ago it was the Order of the Red Star and now—the highest Order in the country!

This attention and generosity of the Government deeply moved me and made me happy, though at the same time it embarrassed me. I am saying this without any false modesty or show-off. My comrades and I had only honestly done our duty, but nothing we did could compare with the courage and heroism of the ordinary Soviet infantry-man during an attack, or a tankman ramming the enemy tank. I thought I should have to work for many years to come in order to be in any manner worthy of so high an award.

On March 2 of the same year Mishchenko, the secretary of the institute, came running into my office with the words:

"Have you heard of the Decree, Comrade Paton? You've been awarded the Title of Hero..."

She was followed by several of our co-workers. I received numerous telephone calls. I scarcely had time to reply to the congratulations and to shake the hands sincerely and fervently offered to me. Tears welled up in my eyes, but I was not ashamed of them. I did not and could not hide my amazement. I was a Hero of Socialist Labour. Could I have dreamt of a higher recognition, since labour had always been the basis and entire purport of my life?

Several minutes later I stood near a loudspeaker and personally heard the Decree broadcast for the second time.

I pictured my whole life to myself. Had I done all I

could and was I doing all I could now? Hadn't I wasted any time in vain pursuit? Had I given myself fully to the service of my Motherland?

No man alive can be his own judge. He can be truly judged only by the people. One thing I knew very well: I had devoted myself to work completely, without reservation; I tried to live in a manner that would allow me to look directly and honestly in the eyes of Soviet people. In those moments I regretted again that the greater part of my life, my young years, had been spent in the stuffy, utilitarian atmosphere of tsarist Russia, where labour was never a matter of honour, but only a means for earning a living.

Many people, besides my co-workers at the institute and at the plant, took my decoration to heart. I was congratulated by perfect strangers and received one telegram after another. I also received many letters of congratulation from directors of plants, superintendents of automatic welding, engineers and workers of various enterprises.

Our automata now welded not only armoured hulls, but also many other types of arms and ammunition. The war was still being fought on Soviet soil, but our flyers were already bombing the lairs of the beastly enemy. The seams on the bomb cases were welded by our automata. The workers from the different plants did not confine themselves to genial words, they also reported on the victorious march of the new method of welding. This made their letters and telegrams doubly dear to me.

15. I FLY TO MOSCOW

At the end of June, 1943, the People's Commissar of the Tank Industry spent several days at the plant. He had come there by plane and was going back to Moscow by the same plane.

The plane was to take off in the morning, and the Commissar spent the last day in Tankograd in the shops, at the proving-grounds and at the railway station. The director of the plant and I escorted him everywhere.

In the enormous assembly shop armoured tank-hulls moved past us on Pullman trucks.

Engines roaring and caterpillars clanging, tanks sped up and down the proving-grounds. Uncommonly quiet and surprisingly prudent tanks slowly crawled on to railway trucks at the station, whence the way ran clean across the country to the front.

Watching the contented smile of the People's Commissar I seemed to take a detached view of the whole picture —from the first seam, which had forever joined two plates of armour steel, to the first shot fired by the tank, which would smash the enemy pill-box.

At that moment I felt as if every tank on these railway trucks, covered with tarpaulin, was taking part of my soul into the fire of battle, raging over a thousand-kilometre-long front. I had given part of myself to each of these tanks, and the agile slender lieutenant, who vaulted on to the truck, was as near and dear to my heart as my own sons. It looked as though the young fellow in the leather jacket were going into battle right from here, from the Tankograd station...

My companions were silent. They, too, may have been gripped by that keen and inexpressible feeling of communion with all the participants in the great fight for the Motherland, which lifts up one's heart and makes one feel brimful with life.

The People's Commissar turned to Maksaryov and me:

"Well, what can I say, Comrades? I can report to the Defence Committee with a clear conscience that Tankograd is doing a good job supporting the front and that, as time goes on, you will be doing it even better."

"We do not think we have reached our limit," Maksaryov said very seriously. "We shall be producing more tanks with each passing day. Right, Comrade Paton?"

I nodded in acquiescence. The Commissar's words gave me something to think about. It was not very long the plant had produced only a few tanks per day, using manual welding.

"What if you flew to Moscow with me, Comrade Paton?"

The Commissar had a cunning look which seemed to say: "Won't the old man be scared by this 'baptism of air' in his seventy-fourth year of life? It is two thousand kilometres in the air, whatever you say..."

"We'll take off in the morning and will land in Moscow in the afternoon. Tempting, isn't it? Or maybe it is too late to grow wings?"

"Why, it's never too late. What's more, I have a good deal to do in Moscow. Let's fly," I answered in the same tone of voice.

"Incidentally, you'll get your 'Star'."

For that alone I would not be leaving the plant at this time. I had already been summoned to Moscow twice to get my Gold Star of Hero of Socialist Labour and both times I asked them to send it to me here, but that was out of question.

The Commissar's plane took off on an early June morning. The ground drifted sideways under the powerful wing and rushed rearwards.

When we had passed Kazan I went to the glazed sunlit pilots' cabin. As long as I was flying why not learn something about the flying instruments and the work of the pilots?

The flyers willingly explained to me the instrument readings and the purpose of the wheel, the pedals and levers.

Taking my seat again I delighted in the fresh air,

coming in through the thin tube above my seat, and surveyed the surroundings with a keen interest.

The Urals with its severe forest beauty, its steep mountain spurs, the lines of smoke-stacks and rectangles of plant buildings had long since receded into the distance. From our great altitude the earth appeared clean, well-combed and ideally even. The villages, groves, ribbons of roads and towns acquired strict geometrical outlines, unusual to the "earthly" eyes.

"You know," I said to the Commissar, "curious thoughts and comparisons have occurred to me now that I have been in the air for the first time in my life."

"What may they be?"

"When we take off the earth we lose our real ideas of the essence of phenomena and of things. From above everything looks beautiful and simple, but lifeless and unreal. Am I right?"

"Why, certainly," the Commissar agreed, looking out of the window.

"To me it's symbolic, you know; in all our research work and scientific experiments we must hold on to the ground. Yes, we must stand with both feet firmly planted on it. Thoughts and dreams may and must soar high, but we can only reach our aims if our practical work rests on the earth, on life and its needs."

"You're absolutely right," said the Commissar.

"It's been my lifelong idea," I continued, "only for a long time nobody wanted it. In the last 25 years, though, I have been more than amply rewarded for the past."

The Commissar nodded understandingly. He knew the history of my life, which I had begun anew at the age of 50.

I was the only person in the plane who had not seen Moscow in the last two years. And what two years! I felt I was getting excited. I, certainly, never did believe the boastful fascist ravings that they had turned the Soviet

capital into a heap of ruins, but I knew that war was war.

At last the magnificent, ever thrilling vision of the vast capital appeared under the wing of the plane and in a few moments obscured everything else.

I pressed my face to the window. Moscow drifted, turned and sparkled with thousands of windows under the wing of the landing plane.

I did not notice the sharp change in the air-pressure. My first and foremost thought was: "Moscow is intact and safe..."

It was like seeing the dearest friend again, the friend who had not only fought off a fatal disease, but who was now greeting you on the doorstep with a smile, outstretched arms and words of love.

Moscow stunned me at once with the stormy vortex of her inextinguishable life. The city had put a greatcoat on, but its face was not gloomy or sullen, but only severe and stern.

Rustling on the asphalt our car sped along the broad avenues of the capital.

The house windows were pasted over with paper crosses. On the roofs there were observation posts and bags with sand. But we could see no signs of destruction anywhere, either in the centre of the city or on its outskirts.

Everywhere—in the public gardens and squares, near the bridges over the Moskva River and on buildings—there were barrels of anti-aircraft guns watchfully trained on the skies. Awaiting twilight—their working hour—silvery barrage balloons were drowsing at their moorings in parks.

No, Moscow was not far enough from the front yet!

"This means we are not doing enough to drive these beasts back into their lairs. We must produce twice, nay, three times as many tanks," I thought.

I realized we were in great debt to Moscow. I ceased looking at her buildings and squares. I searched in the faces of the Moscovites, in their looks and gestures, for an answer to the question as to the spiritual and moral state of the city. There were fewer smiles and merry sparks in their eyes than there had been before the war. The war was still on and was taking the lives of many dear ones. And yet there was something that seemed very clearly to say to the heart: Moscow, like the entire country, feels the hour of victory is near and it will be the hour of reward for all the deprivations, sorrows, superhuman strain and sacrifices, borne by nearly every family.

In a stream of cars our automobile crossed Sverdlov Square, on which there was a good deal of hustle and bustle even in those days. Over the famous colonnade of the Bolshoi Theatre fiery rearing steeds aspired to the skies, while near the theatre, on the site of one of the public gardens stretched ... a potato patch.

It was a small, everyday and simple, but persuasive symbol—a symbol of the enormous and inexhaustible vitality and courage of the city.

It was this potato patch that I remembered more than anything else of my first day in Moscow.

"The Hitler generals boasted in October, 1941, they could see the Moscow buildings through field-glasses, but these potatoes are something they did not see," I thought as I went to my room at the Moscow Hotel.

It was too late to go visiting and I decided to do it the following day. In saying good-bye the Commissar insisted that I take a good rest.

The next morning I went to the State Defence Committee and thence to different Commissariats. The busiest people found time to receive me at once. I was an envoy simultaneously from the Urals, Siberia, the Volga and the Far East. Reports were coming in in those days from all

parts of the country: the welding automata made it possible to double, treble and even to increase ten-fold the production of tanks, demolition bombs and shells.

I knew this gave me the right to demand rather than ask, but there was no need for it. Everybody met me halfway and I was given machines, motors and instruments for our institute shop.

Looking over the warrants I had received I recalled involuntarily how we had set up our shop in that first autumn in the Urals; we had used every piece of old junk we could find around the plant. And today the Defence Committee was charging our shop with supplying many war plants with welding heads.

"We are relying on you and your workers," one of the People's Commissars said to me.

I smiled wondering what the Commissar would have said had he seen our "kindergarten," but explained my smile differently:

"They can be relied on, all right."

I received the Gold Star of Hero of Socialist Labour from Grechukha. I was very much excited as I was taking the high award from his hands and made but a brief reply to his congratulations, though I wanted to say a great deal. I keep the memory of this great event in my heart.

However busy, I always found an hour or two to go to the Tverskoi Boulevard where an unassuming building temporarily housed the Government of the Soviet Ukraine.

Every time I crossed the threshold of this building I felt I was in some very special atmosphere. Here we talked about returning to Kiev as if the last invader had already been thrown out of the Ukraine and all we had to do was order tickets for the Kiev train. But the Germans were still in Belgorod and Orel and secretly nursed a plan for taking revenge for Stalingrad in the area lying between these two cities.

Kiev... People were still being hanged there for a picked up guerilla leaflet.

Grechukha would take me to his office and a moment later I would feel as though we were again in the familiar building of the Supreme Soviet of the Ukrainian S.S.R. on Kirov Street. I always came to the building on Tverskoi Boulevard immersed in thought of welding the sides, heads and floors of tanks, and bodies of air-bombs, while here people were already living for the future.

Grechukha would pose one question after another:

"What are you going to start with when you get back home? In retreating the Germans will undoubtedly try to inflict even greater damage on our industry and we will need your help particularly.

"You have but few people left at the institute, while in the Ukraine you will have to work at dozens of plants. Where do you intend to get the people? Whom should we recall from the army?

"Do you have a plan or at least an idea of what you are going to do when the hour of peace strikes?"

We tried to answer these rather unexpected questions together. Grechukha went so deep into the affairs of the institute that one might have thought there was nothing more important in the plans for restoring the Ukraine. But people kept coming in with urgent reports and he would immediately switch to seeds for the first sowing on the liberated land, pumps for getting the water out of the flooded Donets Basin mines, orders for brick, glass, cement, nails, overalls and boots.

During these moments I pictured to myself dozens of trainloads of Urals tanks going to the Ukrainian fronts, while right behind them were moving other trainloads of tractors, combines, seeders and ploughs. And both the tanks and the seeders were lined up at the gates to the Ukraine. And though not a single inch of the Ukrainian

territory had been liberated as yet, I profoundly believed the hour of liberation would soon strike.

At one of our get-togethers Grechukha announced to me without much ado:

"The Union Government decided to transfer the Ukrainian Academy of Sciences temporarily from Ufa to Moscow before we go back to Kiev. What do you say about your institute?"

I kept silent. This was a good sign. It meant we would really be going back home soon. But to leave the Urals? To leave the Urals and other tank and artillery plants now when the front needed more and more arms? The tanks have to go through the land before the ploughs do...

"I shall have to think it over, Comrade Grechukha," I answered. "I shall have to consult my comrades. And I should like to know personally what good we will be here in Moscow."

"All right," said Grechukha, "think it all over and then decide."

I was seriously upset for a long time. If you look at this proposal from the purely human point of view the transfer to Moscow was very tempting. After the sleepless nights in the Urals, after the malnutrition and other deprivations of the first war years, the appartment inconveniences and other discomforts, the workers of the institute and their families would begin an entirely different life.

But was this the time to think about conveniences and comforts? And will my co-workers and pupils thank me for taking them off the "firing-line" sooner than others? During those years the scientific workers, engineers and laboratory technicians had learned to consider themselves soldiers on duty, and duty is something you have to do to the end.

I did not want to take a hasty decision, nonetheless. I thought I should personally see the Moscow plants first.

I spent four days at the largest enterprises of the capital and visited the plants in Noginsk and Mitishchi. I took Ostrovskaya, who was in Moscow on business, with me.

Like in the Urals, here, too, they knew only one law of life: everything for the front, everything for victory. Here, too, they needed no begging or coaxing to stay at the plant for the second shift; they frequently went without eating for ten hours on end (urgent order!); here, too, working side by side with the regular turner were his pensioner-father, his wife and his schoolboy-son.

And yet I had the feeling it was no use transferring to Moscow. To come to Moscow, to get accustomed to the new place, to make new contacts with plants, to study their production and to break into new branches of industry would all require a lot of time and, who knows, but we may have to "take off" again by then. The very idea that this would tide us over for the few months in Moscow struck me as criminal.

Well? Well, duty to the end!

These thoughts went through my mind as I sat in my hotel room after my return from Noginsk. My mind was made up! There was no use dragging it out any longer; I ought to see comrade Grechukha and tell him about it.

I was about to leave when the telephone rang. It was Khrushchov calling. He had been in Moscow several days now, but was so busy he did not have the time to see me, though he had to and wanted to see me.

"I'm flying back to the front," he said, "but if you can come to the airfield with me and don't mind doing it I shal. call for you and we can talk about everything on our way. What do you say?"

I knew Khrushchov had been at different fronts since the beginning of the war. When our armies were retreating, fighting every inch of their way along the Ukrainian roads, Khrushchov shared all their hardships with them. He took part in the grand battle for Stalingrad, which

ended in a complete rout of the enemy. Since then he had been together with our armies pursuing the retreating enemy. The hour of liberation of the Ukraine was drawing near, and I wanted to believe his coming to Moscow was connected precisely with this.

We met at the lobby of the Moscow Hotel.

"I know all about your remarkable doings in the Urals," said Khrushchov as the car started. "You've kept high the honour of the Ukraine and of Soviet science. But frankly now: are you very tired of all your hustle and bustle?"

I did not care to talk about my fatigue or troubles, since it was something else that agitated me.

"We've been asked to move to Moscow, Comrade Khrushchov," I said. "I've visited the plants and People's Commissariats here, and believe we'll do much more good in the Urals. There is no sense in our coming here."

Khrushchov scrutinized me, as if weighing every word I had uttered.

"Is that the way you feel? I agree with you. Your institute is in a special position. Keep up your good work in Tankograd another year or so... Why, we need no diplomacy. From there you'll go right home, to Kiev. You can, probably, hardly wait. It's all right, though, we'll soon meet in the Ukraine."

Not only in his words, but in his voice, too, I heard so firm a confidence that I had no more doubts left something very big and very important was on foot.

"No," Khrushchov continued meditatively, as if in response to some secret thoughts, "we don't have long to wait. Get ready, Comrade Paton, there'll be plenty to do for your automata in the Ukraine."

I beamed with joy.

"You've simply infected me with your cheerfulness. I've taken a new lease on life. May I hint to our comrades about it?"

"Why hint?" Khrushchov laughed. "Just tell them we'll be in Kiev soon."

At the airfield, as we were taking leave of one another, Khrushchov held my hand a little longer.

"Well, good-bye and good luck. But, meanwhile, remember: the soldiers at the front will thank you for every additional tank. Berlin is still very far off."

"We shall spare no efforts. Tell them there ... in the Ukraine!"

Khrushchov was followed into the plane by a stocky, well-built man with general's shoulder-pieces. I knew General Vatutin, the Army Group Commander, from pictures and now easily recognized him. The soldiers called him "General Forward."

I followed the plane of Khrushchov and Vatutin with my eyes for a long time. After making a farewell circle over the airfield the plane took to its course. Could they be carrying the cherished order so impatiently awaited by millions of people in the Ukraine? The order that will set in motion armies and fronts with thousands of tanks rushing ahead to pave the way for the infantry? And on the steel breasts and sides of these tanks there are seams welded forever, seams that do not fear the bites of the fascist "Tigers."

My thoughts followed the plane to the meandering line of the front, to the famous salient in the Kursk bend where only a week later the great battle for the Ukraine began—the battle after which the fascists could never recover.

Thoroughly camouflaged, the Urals tanks and self-propelled guns stood under forest cover, while the soldiers calmly jested in their dug-outs:

"Against our 'little boxes' no 'Tigers' or 'Panthers' have any guts."

The powerful spring of the future offensive was still very tightly coiled, but in my mind's eye I already saw

the distant blue waters of the Dnieper and the outlines of the beloved city on its steep banks.

The plane faded in the June sky vibrating with heat.

I turned to the car. Now I was doubly sure there was no sense staying in Moscow any longer. Many more tank armies had to be born in the Urals smithy... Back home, to the Urals, as fast as possible.

Back home? Why, yes, during the war the Urals had become my second home.

16. KIEV LIBERATED!

I had hardly reached the Urals when the historic battle at the Kursk bend began. Hitler's divisions were bleeding to death in an attempt to break through the wall of our defence. Their main trump—the heavy "Tiger" and "Panther" tanks, the entire armoured menagerie, failed to create the impression the Hitler generals hoped for. Soviet soldiers wrung the necks of the "Royal Tigers" as skilfully as they had done to their predecessors.

Having worn the enemy down during the defence our troops took the offensive.

In those unforgettable days we learned that the plant was given a very important Government assignment. I was summoned before Maksaryov, the director of the plant.

"Our medium tank T-34 is an excellent machine," he said, "but it could and must be even better and more perfect. The front insists on it. Without stopping production for a single day we must re-equip our shops for mass production of new units. The problem is as acute as all that. We will have to create our new technological equipment as we go along. We are pinning great hopes on you, Comrade Paton. Only high-speed welding could help us now."

"We'll do all we can," I answered. "Where is your tightest spot?"

"We will have a lot of difficulties," Maksaryov emphasized, "but welding the commander's turret will be the hardest. I want you to take this upon yourself."

There is no need saying how we all took the front's assignment at the institute. I called a conference at once. The conference decided to develop a special machine for the automatic welding of the turret. The difficulty was that the turret had several complicated circular seams, and the welding machine had to have two working places.

This did not disconcert Sevbo, our chief designer.

"We can do it if we have the time," he said.

"How much time do you need for this work?" I asked him.

"A month and a half if everything is well organized," Sevbo answered.

"That won't do. You can only get half that time."

Sevbo was silent. I knew I was giving him a very hard task. During the war our designers had learned to work twice and even three times as fast as they did before, but now I was demanding a speed unusual even for that time.

I wondered what Sevbo would say.

"It is very, very hard," he said after considerable reflection, "but we must try. An idea has just occurred to me, and we may be able to cut the time by a few days."

We all found out what the idea was when the designing office set to work. Savenko and Ivannikov worked on the design under Sevbo's supervision. The latter drew up a schedule according to which the design of the machine and all the working drawings were to be ready within 15-20 days. Only two weeks were allotted to the manufacture of the machines and to putting them in operation. 15-20 days instead of a month and a half.

The way we had worked before would no longer do. Sevbo broke all old traditions and the designing was now

being done by high-speed methods. Savenko and Ivannikov worked for all they were worth, sending the drawings to the shop as soon as they were ready, while the shop lost no time waiting for the full set of drawings and immediately manufactured the separate parts and units.

Fifteen days later, when the designers finished their drawings, the first units had already been manufactured. Another twelve days and the machines were installed in their places.

I admit I was astonished. The time limit we had fixed was more than short, but our workers managed to stay within this limit.

Now we had to put the machinery in operation and I sent the most energetic and skilful people to the shop.

During the first days they did the welding themselves and taught the girls who were to operate the new machines. Our instructors could hardly stand on their feet. Sometimes they were too tired to go home and using their padded jackets as pillows they fell asleep right in the shop on the hard hull of a tank. No one complained of fatigue or overwork or of the fact that they had to work with Udmurt girls who had a poor command of Russian. Everybody bore in mind one thing: the Red Army was on the offensive and it could not wait.

In less than a month after receipt of the assignment by the plant the idea of tank-designers was embodied in an improved battle-machine and the front was given an even more powerful tank.

Never before had we listened with such joy and enthusiasm to the reports of the Sovinformbureau.

An irresistible avalanche of attacking Soviet troops was rolling through the Ukraine, and we felt as though we were moving ahead along with them.

We were getting closer and closer to our dear Kiev...

All of our cities are equally dear to the hearts of Soviet

people, but there is a special joy everybody can understand, when the hour of liberation approaches for the city, where one had lived for decades and had spent the best moments of his life.

The reports increasingly mentioned the tank armies and formations, as well as the glorious names of their commanders, already very well known in the country. The newspapers described more and more the deeds and skill of the tankmen. And though we had no way of knowing where the tanks, welded by our automata, were, we thought they were everywhere. We were, probably, right and it felt good to realize that in this grand offensive we, too, had our share.

And then we learned that the Soviet troops had forced a crossing over the Dnieper in the vicinity of Kiev.

I was amazed that this remarkable feat was accomplished with the aid of the simplest ferrying means: fishing-boats, found on the spot, and rafts made there and then. Moving ahead of the echelons, which were carrying the pontoon bridges, our advancing troops crossed the Dnieper on the march under heavy enemy fire. Military history can hardly cite another example of so daring a forced crossing of a big river on so large a scale. This feat bespoke the mass heroism, courage and inflexible will-power of Soviet soldiers. It was with great satisfaction I read in the newspapers that more than 100 people, who had taken part in the storming of the Dnieper, were awarded the high title of Hero of the Soviet Union.

On November 6, 1943, on the eve of the great October holiday, the Red Army entered Kiev. The first to break into its streets were the tank units.

Kiev was free!

It is hard to describe what was doing at the institute that day. Two years we had awaited this great moment; for two years we had read in the Moscow and Ukrainian newspapers of the woes and sufferings of our city and for

two years we believed the hour of reckoning for the fascists would strike. It was so painful to see in a German magazine pictures of city ruins and of a stone chaos on the Kreshchatik.[1]

During the last days preceding the liberation of Kiev we had kept the radio permanently turned on; we were all arguing about the date the city would be liberated. Many of us had heard this news at the plant gate on our way home from work. It was a severe Urals frost, but we all felt hot. The people tore their hats off their heads, threw them in the air, embraced and kissed each other.

Many of us had a bottle of cherished wine, kept for this solemn occasion, but nobody wanted to drink alone and that evening we all drank our personal reserves collectively in the dining-room of the plant. Makara claimed a double portion as the "prophet." He was the first to foresee the Hitlerites would be driven out of Kiev on the October holiday. We drank to our Great Communist Party, our heroic Soviet people and our Army.

I was beginning to ponder our future and I was not alone. Many of our workers wanted to go back home immediately. I was also homesick, but I felt that as long as the war was on, as long as there were still many hard and stubborn battles ahead, our place was in the Urals, at the war plants which were forging our victory.

17. I JOIN THE PARTY

In the spring of 1943 I made a business visit to Alentiev, the Secretary of the Party District Committee. This happened soon after I had been awarded the title of Hero of Socialist Labour. Congratulating me he asked:

"Why aren't you in the Party, Comrade Paton?"

[1] Main thoroughfare in Kiev.—*Tr.*

The question was asked point-blank and I answered it as frankly:

"I've been thinking about it for several years now, but haven't been able to make up my mind somehow."

"But why?" Alentiev was surprised.

"One must have the right for it, must earn it."

"You've earned it, all right," the Secretary of the District Committee said.

This conversation perturbed me.

As a matter of fact I had thought of joining the Party even before the war. My first meetings with Khrushchov in Kiev and later in Moscow, and my work in the Council of People's Commissars of the U.S.S.R. had brought me ever closer to the Party. From now on all my work was determined by its assignments, and my desire to become a Party member strengthened. The way the Party had handled our new progressive method of welding and had spread it on an unprecedented scale convinced me the Communists in our country were the most active fighters for the development of advanced science and engineering.

During those months I had dealings with prominent leaders of the Party and the Government, and those people captivated me with their far-sightedness, their breadth of mind and their business-like methods. I realized they had been educated by the Party.

The Great Patriotic War broke out and I could appreciate the mind, grandeur and will of the Communist Party even more.

During my lifetime I had witnessed two wars prosecuted by tsarist Russia. I've already told my readers about the shame and pain I had suffered at the time. It was quite different now. I was proud of my motherland.

I was enormously impressed by the transfer of the large-scale industry to the East. Any other government, but the Soviet Government, any other party, but the Communist Party, would have lost heart, wavered, become panic-

stricken and would have abandoned everything to the enemy as it had happened in the western bourgeois countries. What happened at our plant alone showed the powers latent in the Soviet people. Here is another example. The plant needed armour steel for the production of tanks, but there was no way of getting it from the South of the country any more. Within literally several weeks we began receiving armour plates from another plant, which had launched their production right there in the Urals, not far from us. I knew dozens of such facts. Anticipating an attack the Party had built, beforehand, a powerful industrial base in the Urals and in Siberia which was rapidly developed during the first years of the war.

The gigantic organizational will and power of the Party amazed me. Was it not the Party's work that the plant, which had produced two or three tanks per day during the first months, was now turning out dozens of times as many? If anybody knew the efforts it required, I certainly did!

We were closely connected with many war plants and I saw the same picture everywhere. Whereas in the beginning of the war our peaceful country experienced a shortage in armaments, towards the middle of the war the Red Army was amply supplied with everything. I was persuaded once more that the Party did not waste any time in idle talk.

One day I read in a newspaper that Goebbels had taken terrible offence at the Bolsheviks. The Russians, you see, had hidden from the whole world their industry in the Urals and in Siberia and, for some reason or other, failed to supply the fascists with a detailed list of their plants in the East of the country.

The second "Soviet dirty trick" was that the Russians had concealed from Goebbels several millions of population and unexpectedly put out about fifty new divisions in the field.

I laughed heartily at these "offences." It was not the number of the plants, nor the statistics the fascists had overlooked, but something way more important; they had failed to see the spiritual power and unity of the Soviet people.

I remember very well how the plain Russian people went to the Russo-Japanese and to the First World wars, hating their rulers who had thrown them into a blood-bath and had left them without arms. The people in the rear had had the same attitude to those wars.

Now I saw an entirely different people and an absolutely different war. Mothers, wives and children knew their loved ones were fighting for their own rule, for their rights, for their freedom, and without putting on airs did all they had to under the circumstances.

I shall never forget the women of those years. Hundreds of them came to our plant, frequently together with their young sons; they did the hardest men's work, spent hours in queues and reared their children, taking the place of their fathers; they never buckled under the weight of grief when notified of the death of husband, son or brother. They were real heroines of the labour front, worthy of admiration.

Or take the young people at the plant. They besieged the war commissariat with requests to send them to the front, finding it too easy in the shops, while, for months running, they had no days off, did not have enough food or sleep, and wore canvas shoes in winter...

And the working people evacuated from the Ukraine! These people worked particularly hard, I would even say, with a vengeance; they were always the first to stay for another shift or volunteer for harder work. Not for a moment did they feel they were guests or strangers in the Urals. They were received as brothers, as members of the single Soviet family. The sons of the Ukraine were fighting the enemy both on the front-lines and here in

Tankograd, while the young men from the Urals drove through the fields of the Ukraine the tanks built by Russian and Ukrainian workers and engineers in a city far removed from the front.

I often listened together with the men and women workers of the plant to the reports of the Sovinformbureau. How their eyes sparkled, what joy illumined their faces when the radio informed us of a new victory of the Red Army! The liberated town might be thousands of miles away, but for the people here it was a holiday just the same!

I had met many prominent workers of the tank-building industry—V. Malishev, the People's Commissar, famous designers, directors of the largest tank plants and dozens of engineers. All these captains of industry, big and small, had given a lot of their selfless work, health and strength to the organization and development of the tank industry at the Urals and other plants.

I saw with my own eyes that in the 25 post-revolutionary years the Communist Party had educated numerous people, the like of which had never existed nor could have existed before. They had infinite faith in every word of the Party and followed its instructions always and in everything. A little introspection showed me I, too, had changed beyond recognition.

One must join the Party with a pure and open heart and hide nothing from it. My path had been complicated. I had not become what I now was all at once or without hesitation.

On December 13, 1943, I had a telephone conversation with Khrushchov. That was after my illness when I was at the Sverdlovsk hospital. Khrushchov was as solicitous of my health as ever.

It was at the Sverdlovsk hospital that I thought a great deal about my life and made up my mind to ask the Party to take me into its ranks.

Four days after the telephone conversation I wrote to Khrushchov. I thanked him for his solicitude and told him I was convalescing after my illness as far as my age would allow and was "training" my overstrained heart by work.

In the letter I gave expression to my innermost thoughts with extreme frankness. I was sure he would understand me right. I wrote:

"During the war I have thought a great deal about joining the Party. I wanted to consult you on this question the last time we met in Moscow in June. I regret to have been unable to do it.

"Two considerations put me out of countenance: I was afraid people might not believe the sincerity of my motives and might think I pursued personal interests.

"Both of them seem to have fallen away now. My devotion to the Soviet system has found its confirmation in the work I have done during the war.

"The question of personal interest has also fallen away since the Party and the Government so generously rewarded me with marks of highest distinction last year.

"This is why I decided to write an application for admittance to the Party and send it to you personally.

"As regards my application, please, use your own judgement. If you find it inappropriate, destroy it.

"Sincerely yours,

"E. PATON."

The following is the text of my application for admittance to the Party, which I enclosed in the letter:

"When the Soviets took the government of our country in their hands I was 47 years old. Having worked for many years under the conditions of capitalism I had adopted its world outlook.

"In the beginning the Soviet government mistrusted me, which I felt time and again. I believed the under-

takings of the new government unreal, but observing it closely I continued to work honestly, since labour has always been the sole purport of my life.

"When I studied the first five-year plan I did not believe it could be fulfilled. Time marched on. When work was launched on the Dnieprostroi, which the tsarist government had been unable to cope with, I began to understand my error. With the completion of each new construction, with the reconstruction of Moscow and with the other major undertakings of the Party and the Government my world outlook increasingly changed. I began to realize I was being drawn to the Soviet rule by the fact that the Soviet Government considered labour, which had been the basis of my life, of paramount importance. I was convinced by facts and I realized that I was being regenerated under the influence of the new life.

"The Great Patriotic War proved a brilliant confirmation of the power and stability of the Soviet system. In my mind's eyes I saw the two preceding wars—the Russian-Japanese and the First World War. I was able to compare what had happened then with what was taking place during the Patriotic War. I am amazed at the mettle and heroism with which the Soviet people are struggling at the fronts and in the rear under the firm leadership of the Party and the Soviet Government.

"When the Patriotic War broke out I knew what I could do with my knowledge and worked at the defence plants in the Urals together with the staff of my institute. We did our best to aid in the defence of our Country. The Party and the Government generously rewarded me for this work, thus making me understand they trusted me.

"This entitles me to the application for admittance to the Party in order that I may continue and consummate my life of work under the banner of the Bolshevik Party.

"E. Paton,

"Hero of Socialist Labour."

In this application I summed up my life frankly and honestly. It was now up to the Party to decide whether I had the right to be in its ranks.

I awaited the reply in great agitation. Nobody, not even the members of my family, knew anything about it, since I could not be sure beforehand of a favourable reply. All those days I lived under a strain, but tried to hide it from the people around me. My son Boris saw me write some letter on especially good paper I had kept for particular occasions. I passed all his hints in silence.

Towards the end of January I felt bad again and stayed in bed in the evenings. On one of these evenings the director of the plant sent for me. My family protested against my getting out of bed, referring to the frost and the state of my health, but I seemed to divine the reason the director had sent for me and had it my way. I was helped to get dressed...

Several minutes later I was talking to Khrushchov over the telephone. He congratulated me on being admitted to the Party and told me the Political Bureau had adopted the decision on January 27. So soon! To think I had been admitted to the Party by the Political Bureau of the Central Committee of the Communist Party of the Soviet Union...

I was completely taken aback and answered all of Khrushchov's questions by inarticulate thanks.

Within a few days the Secretary of the City Party Committee handed me my Party membership card. I was sick when I went to the City Committee, but did not want to postpone the receipt of the Party card. My whole life now merged with the life of the Party till my last day. A lot of things were now acquiring a different aspect...

Registering with the Party organization at the institute I said in jest to Asnis, our Party organizer:

"You have been my subordinate, but now I am also yours."

Asnis smiled:
"Not mine, but the Party's, of course."
"I've always heeded the Party," I answered, "but henceforward I shall do it even better."
It's not for me to judge how I've kept my word, but I've always tried hard.

18. TOMORROW—THE UKRAINE

1944 was very much unlike the years immediately preceding. We continued to expand our work at the defence plants and continued to live by the war, by its interests and needs. At the same time we were thinking about our impending return to Kiev and the work, which was awaiting us in the Ukraine.
As early as the summer of 1943, after my return from Moscow, I called a general meeting of the institute workers. I told my co-workers all I had seen and heard in the building of the Ukrainian Government. Then I said:
"The Academy is moving from Ufa to Moscow. I refused to go. What do you say?"
No one expressed any desire to move to Moscow. Everybody understood our path ran directly to the Ukraine.
The farther our troops advanced the more information we received about the terrible damages wrought by the fascists to our plants, electric stations and mines. We knew that in the Ukraine we would be immediately required to do the best we could to help restore the industry. There we would have no time for long preparations.
We discussed all this in great detail, including the work we would do from the very outset. I reminded my fellow-workers it wouldn't do to wait for the plants to be put in operation, since high-speed welding could and should play an important part in their reconstruction.

"That's quite true," Kazimirov supported me. "Enormous quantities of metal structures will be reconstructed and built anew. There will be iron beams, pillars, water and gas mains for metallurgical plants and mines, crane girders, etc."

"That's exactly what it'll all begin with," Rayevsky joined in, "metal structures and large-diameter pipes. And this is what we should devote our greatest attention to."

We all realized there would not be enough manual welders to do all that work at hundreds of plants and mines. Where were we to get the thousands of these specialists now? Only high-speed automatic welding could help as it did in organizing the mass production of tanks.

We aimed our principal attention at the Donets Basin and at the Dnieper and Azov regions—the basic industrial centres of the Republic.

Everybody was getting ready to work in the Ukraine. The shop was setting up a reserve of deficient parts for welding heads, while the technologists and designers were accumulating drawings for different machines. The plant presented us with cable, non-ferrous metals, machines and equipment for the manufacture of flux. We all remembered we were going to an area devastated and turned to ashes by the enemy.

I fell ill again and very seriously this time. My arms and legs swelled up, bloated out with dropsy, and I was bedridden. I suffered very much because of my forced helplessness and was afraid a change for the worse in my health might prevent me from working.

One day I asked several of my co-workers to come and see me. They sat at my bedside, joked and tried to divert me with their chatter.

I put up with it for a while, but, at last, could contain myself no longer:

"Comrades, I did not ask you to come here and entertain a sick old man. Let's get down to business."

"We don't take any orders from you today," one of them joked.

But they had to submit. We discussed our new tasks long and thoroughly, and came to the conclusion we could no longer use any primitive methods and had to base our work on a single state plan for employing high-speed welding. We, thus, hit upon the idea of sending our delegate to see Khrushchov in Kiev. This delegate was to go with concrete proposals and a list of plants at which we thought it necessary to begin work at once.

"As for us, you should not ask for any more than is absolutely necessary to restore the institute," I said.

"We are not going there to rest after the Urals, but to work full time; we will do peace-time work in a war-like manner."

We also discussed the draft text of our appeal to Khrushchov. My co-workers left in a cheerful and elated mood, while I thought I felt much better. Unfortunately, it was a delusion.

I appointed Sorokovsky, a scientific worker, to be our delegate. He departed with my precise instructions attended by the warmest wishes of the whole staff.

Sorokovsky was taking a letter to Khrushchov with the request that the Government issue an enactment for introducing automatic welding at the Ukrainian plants under reconstruction.

I pointed out in the letter that during the first post-war years there would be a great shortage of skilled workers, which will put on the agenda the problem of the maximum curtailment of manual labour and the mechanization of technological processes. For want of experienced and competent welders the plants will have to resort to automatic welding. Therefore in the plans for reconstruction of the plants with a big volume of welding we must make sure that the transfer from manual to automatic welding be effected at the very outset.

The main direction of our future work was thus becoming increasingly clear. We were gradually being drawn into it. Rayevsky and Kazimirov, our scientific workers, began to elaborate the problems of welding metal structures and in time did no other work but this. The designing bureau was already designing machinery for different types of welding. At the end of 1943, my older son Vladimir also came to work at the institute. He was testing his abilities as designer for the first time. For his début Vladimir was given an important assignment—to design a universal automatic head for welding metal structures.

In April, 1944, the Central Committee of the Communist Party of the Ukraine and the Council of People's Commissars of the Ukraine issued an enactment "On the Measures for Introducing Automatic Electric Welding at the Plants Being Reconstructed in the Liberated Regions of the Ukraine." In accordance with this decision 12 plants in the Republic were to introduce automatic flux-welding as early as 1944. The institute was in the Urals as yet, but its work in the Ukraine was instantly included in the great plan for peaceful construction.

I ordered preparations for departure. A hard but glorious period of our life, connected with the Urals and our work at its war plants, was coming to an end. The institute was getting ready to leave. Our machines, materials and equipment alone required no less than ten waggons in our estimation. What we had at our disposal now differed very greatly from what we had had in the beginning of the war.

There was only one dark cloud—my increasingly exacerbating illness, my almost motionless state. The physicians demanded that I go to a hospital for a long time and place myself in the care of medical specialists.

On April 8, I was summoned by Government telephone for treatments at the Kremlin hospital in Moscow.

It was hard for me to leave the institute at such a moment, but I had no right to disobey the physicians: I wanted to live and do some more work yet.

The whole institute came to see my wife and me off on the train. Our parting was particularly stirring, for we were to meet again only in Kiev.

19. OUR CONTRIBUTION TO VICTORY

At the Kremlin hospital I stayed from the middle of April to June, 1944, and then spent more than a month at a sanatorium in Uzkoye, near Moscow.

I was treated thoroughly. First I was bled and then, in a short time I was emptied of 16 litres of Urals water. I submitted to these unpleasant procedures, intended to rid me of my dropsy, but suffered very keenly for being away from the institute.

I pleaded with the physicians to do anything they wanted with me as long as they let me go to Kiev really soon, but they invariably told me they would put me on my feet in no time if I exercised patience. And patience was what I did not have.

I reserved for myself the right to correspondence and later obtained an even greater concession—visits of our institute workers on urgent business, of which there was always a good deal, especially now that the institute returned to the Ukraine.

In my first letters I advised on the organization of the institute's transfer and its placement in Kiev (the Ukrainian Government gave us the choice of three buildings), but before long our correspondence treated more complicated problems—the institute's themes and the methods of carrying out the most important work. I took a new lease on life. True, watching my correspondence grow the physicians protested at first, but, finally, reconciled themselves to it.

I argued with them:
"Without this I shall be getting well much more slowly.
"The fresh air of life is, at times, much better than all your drugs."
"That's a moot question," the physicians answered, but no longer insisted on having things their way.
I had a lot of spare time, this being my first forced idleness in many years. In bed I summed up certain things and drew up plans for the future.
In the evenings the windows of my hospital room were more and more often illumined by the reflection of the fireworks sweeping through the Moscow skies, and I heard the victorious thunder of artillery salvoes. The capital of our Motherland saluted now one, now another front for the liberation of Soviet cities. To raise the red banner over a city many thousands of people sacrificed their lives, while millions of other people worked untiringly in shop and field.
We, too, made our contribution by introducing the new high-speed welding method into the defence industry. During three years of war the institute did the work that would have required 8-10 years in peace-time.
High-speed flux-welding had not only won general recognition, but had become the principal technological process in the armoured-hull shops.
Thousands of tanks had come out of the shops with their seams welded under flux. Towards the end of the war there were no more tanks with seams welded manually. Production of tanks for the front had increased several-fold.
More than 100 of our machines were operating at the country's war plants by that time. They welded not only heavy and medium tanks, but also air-bombs, certain types of artillery pieces and special kinds of ammunition.
The comrades at one of the plants figured out that the work of the automata had saved their enterprise 5 million

rubles, while another plant economized some 3.5 million rubles in one year alone.

If we were to stretch the seams, welded by our automata in Tankograd in the course of three years, along a railway line they would extend over 6,000 kilometres. This silvery string would run from the Urals forests to the Kiev orchards and thence to Berlin and farther. A lot more armaments was produced with the wire and electric power saved by our automata. At one of the Urals plants alone the automata replaced 300 skilled welders, and at one of the Volga enterprises—250.

I was also very happy because automatic welding had made our tanks stronger, more fireproof.

Our plant had frequent visitors from the front-lines; we wanted to know how our tanks behaved in battle and listened intently to their stories. We learned that the tankmen very soon appreciated the greater strength and reliability of the hulls and felt more confident under their protection.

One day we heard the following front-line legend:

In the beginning of the war an old academician moved together with his young co-workers from Kiev to the Urals. They had been sent there by the Party. The old academician was charged with checking up on all tanks produced by the plant. And so this academician with a long white moustache began to wander through the shops, stopping at every tank and sounding all the seams welded by automata. And if he said the tank was all right, you can take my word for it—it was all right and would never go back on you in battle.

I was deeply moved by this naive story, which so fancifully reflected what we were actually doing.

Together with all of our people we craved for victory over the enemy as soon as possible and with the least loss of the lives of our loved ones. It was for this we were working at the country's defence plants and in this

we saw the calling of Soviet science during the war.

Work in the name of victory, in the name of mankind!

This is the briefest summary of our work for the front.

We ourselves and our brain-child—high-speed automatic flux-welding—were enormously benefited by this work. From now on our welding left the laboratory forever and entered on the wide path of industrial employment. With its incontestable advantages automatic welding had won for itself the right to life and recognition. To the brand: "Elaborated at a scientific-research institute" life had made an essential amendment: "Tested at dozens of plants."

We were aware of the revolutionizing power our welding method was for industry. Both my young co-workers and I were certain we had taken the right decision—concentrate all the efforts of the institute on the elaboration of one pivotal, central problem, hit at one spot, aim at one point. This idea, realized for the first time during the war, had yielded valuable results to our industry.

Our work at war plants proved a fine school for all of us. Our scientific youth was offered in the process of its formation and maturation a broad field for initiative, daring and immediate realization of its accomplishments. Our young workers learned by their own experience that the only scientific discovery that has the right to live is the one which had stood long tests in shops.

Our youth had also learned another significant truth. Our institute was no place for theoretical work unconnected with life. I do not remember a single instance during the war when we had advanced a theoretical problem for its own sake. In solving some important practical problem we usually first elaborated its theoretical basis. This was what we did in developing the technology of armour-welding, in our search for a new flux, in studying the problem of the influence of tension in the circuit on the

quality of seams and in investigating the process of flux-welding.

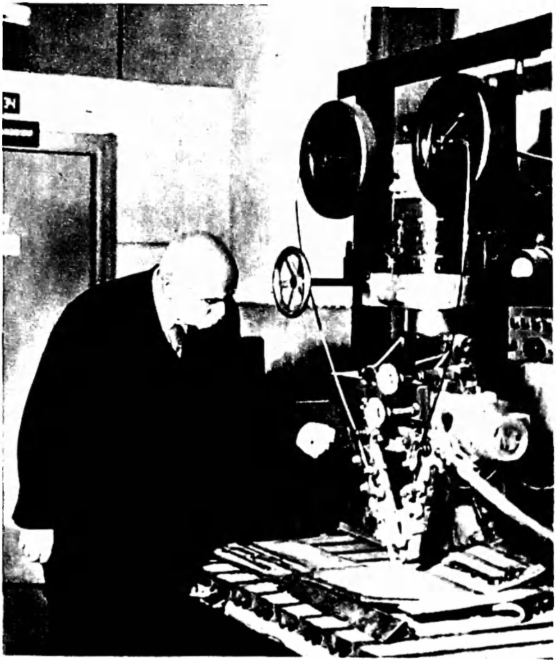
Yes, we were practical people, but never neglected theory. During the first months of the war we introduced what we had accumulated before. But life itself, our work at the plants and the difficulties of war-time had imperatively posed new problems. They called for short-range research work with an immediate yield. To be sure, these were only rudiments, first outlines, rough draughts, so to speak, but they often served as points of departure for serious scientific work. Even if a lot of it had to be revised and supplemented later, the basis had been laid. But such works as our new principle of operation of our welding-heads and the investigation of the process of automatic flux-welding had greatly enriched the theory and practice of our domestic science of high-speed welding.

Our scientific workers had acquired extensive experience and had learned new methods of work. They had learned to see to it that every investigation pursue a concrete aim and at the same time advance and develop theory.

In the beginning of 1944, the Sverdlovsk Industrial Institute conferred the degree of Master of Science on our senior scientific workers—Asnis, Sevbo, Kazimirov, Rayevsky, Sorokovsky and Slutskaya. Each of them was able to report such research and its application in industry to the Scientific Council of the Institute that the right of these people to a degree in science evoked no doubts.

I have already described the conditions under which B. Paton and A. Makara had conducted their experimental research. This work subsequently entitled them to the degree of Master of Science and served as the basis for their theses.

I am trying to narrate all this as briefly as possible in the form of general summaries. At that time, at the Kremlin hospital, they appeared to me not as recollections, but as living reality inseparably connected with our



E. Paton before the first model of the two-arc automaton

morrow, with our forthcoming peaceful labour. In our preceding experience I searched for and picked out what we might need subsequently, at the same time checking up on how my views and methods had stood the test of life. I wanted to go back to Kiev with the firm and precise knowledge of how to organize the work of the institute and where to aim the energy of my co-workers.

The war had taught me that the close contact between practice and science is invincible. I was now thinking of the ways and means of making this contact even more fruitful in the matter of reviving our liberated Ukraine.

20. BACK TO PEACEFUL LABOUR

I returned to Kiev in the beginning of July, 1944.

I was greeted at the terminal by my family and many dear friends. After mutual inquiries into the state of health we began talking about our affairs right there and then, no one being able to refrain from this eternal theme for even a short time.

I went home for only two hours and thence to the institute.

On the way I managed to observe out of my car the charred building frames, the terrible ruins of Kreshchatik, the shapeless heaps of stone, the coiled and tangled-up iron girders. Instead of beautiful tall buildings I now saw lone wrecked walls.

Kiev was badly wounded and mutilated, but it was living a full life, nevertheless, and I could sense the fast tempo everywhere. The deep, bass hooters of the plants and the long, shrill whistles of the locomotives merged in the air filled with the aroma of the capital's gardens and boulevards.

The chauffeur told me that the day after the liberation of Kiev the long hoot of the Lenin Forge was heard over

the city. The first workers to return to its shops were making it known they were back on their jobs and were calling on their townsfolk to work for the revival of their city and of the Ukraine.

My institute associates told me about their trip home from the Urals. Their train was constantly outrun by trainloads of armaments for the front moving westward in an unending stream. Hundreds of trucks were loaded with tanks, our tanks! On hundreds of others there were planes, guns and mortars.

In Darnitsa, very near Kiev, the institute train had stopped side by side with a military train. Our workers went to see the soldiers who proved to be tankmen. On their tanks they saw our seams, the seams welded by our automata.

It was a happy and hearty meeting. The tankmen fervently thanked their friends—the young scientists. Both the tankmen and the scientists were impatient. The former were anxious to catch up with the attacking troops and get into the battle, the latter could hardly wait for the moment they would take up another fight—the fight on the labour front.

Through the train-windows the workers of the institute saw the blown-up stations and water-towers, villages burned to the ground and uncultivated fields. In Darnitsa, our workers recalled, they had seen a picture of even more terrible destruction. Plants, large railway structures, hundreds of houses, public buildings were all razed to the ground by the retreating invaders.

Our people looked at this sad spectacle with a heavy heart. All they had formerly imagined faded into insignificance before what they saw now.

Going back to their carriages they all kept saying:

"What can we do to produce more? How can we help our people heal their heavy wounds as fast as possible?"

Suddenly everybody saw a bright bluish star on one of

the buildings under reconstruction: an electric welder was joining the ends of two girders with a melting rod. Where there is reconstruction there is welding.

I listened to these stories and thought: my young friends are ready for hard, very hard work and do not even care for any rest or a respite after the Urals. This is a guarantee that we will cope with our new tasks...

What were we to begin with? What were we to tackle first?

We had to put our new premises in order, set up laboratories and a shop, hire workers, arrange the personal affairs of our staff and at the same time launch extensive research, produce welding equipment, establish relations with plants, design machines for them and render them technical aid and consultation.

We had to do all this at once and under the hardest conditions of the end of 1944 and the beginning of 1945, when a few boxes of pane-glass constituted a problem and finding two or three good turners was considered a most difficult task. We were beset with cares—big and small—on all sides, and each of them required immediate attention.

Our workers and their families had no permanent lodgings as yet and lived in hostels, or with friends or relatives, but our scouts had already gone to various plants in every part of the Ukraine. Our representatives had made their appearance in Dniepropetrovsk, Kharkov, Stalino, Makeyevka, Mariupol, Kramatorsk and other industrial centres, in fact, on dozens of plants and construction sites all over the Ukraine. They were ascertaining what aid was needed from the institute, checking up on our initial plans, and preparing agreements for introducing high-speed welding.

Like in the Urals we did not wait to be asked for help, but searched for things we could turn our hands to.

One of our instructors returned from Voroshilovgrad and reported:

"There is work for us on repairing and manufacturing new boilers."

Another one came back from Makeyevka saying:

"Welding structures is what they need most."

Still another arrived from Mariupol stating:

"Production of tank-cars is being launched there. The shops have not yet been fully restored and the work is done outdoors, but they depend on us."

Our instructors had visited all the twelve plants assigned to us by the Government. By September, 1944, we had already supplied these plants with working drawings of our welding machines, while the institute shop was busy assembling welding heads, control panels and flux apparatus. The plants knew that as soon as they got their machines ready, our instructors would visit them again and would stay there as long as necessary to make the machines run flawlessly.

At that time, however, the institute lived and worked under very hard conditions.

In cold weather we worked in our overcoats, felt-boots and fur-caps. The designers, who spent nearly the whole day at their draughting-boards, literally froze and their fingers were unable to hold a pencil. Time and again they would run to the laboratory and warm their hands on the welding arc. There was a shortage of electric power in the city and our technologists had to perform most of their experiments at night, when we were given a little more power.

We were cooped up in a small, uncomfortable building, which would no longer do for us considering the plans we had for the future. The Government had granted our institute a fine and spacious building, but after the war it needed considerable repairs and though everything possible was being done to expedite them, and the People's

Commissar in charge of construction often visited us and personally supervised the work, it was taking too long, since there was a shortage of workers and materials.

The delay in moving to our new quarters could have been a big hindrance to our work. Something had to be done.

In the winter of 1944-1945 I summoned several of our scientific workers:

"They will hardly like my order," I thought, "but I have no alternative."

"You know how we stand with the repairs, comrades," I said to them. "We can't sit around and wait till we get it on a silver platter. We shall have to become builders for some time ourselves. Three of you (I called their names) are appointed foremen; one of you takes charge of the laboratories, another—of the equipment, and the third—of the furniture. The rest will have to glaze the windows, get the laboratory utensils, paint the walls, etc. You may get started."

The faces of the workers expressed surprise and some even offence and resentment.

"But we are up to our necks in work as it is. Besides, must we, scientific workers, do all that?" someone asked.

"All this is true, but you must realize why we have to go the limit," I answered. "Without a new, substantial base we can't even think of doing our work on a large scale. Every single day counts."

Most of them agreed with me, but on some we had to exert "pressure" by making them understand that we would not tolerate any lordliness or "this-is-beneath-my-dignity" stuff at our institute. I remember how some of our workers came to watch one of the senior scientific workers, who coped very well with the hard trade of a glazer; later other workers also learned additional trades.

In the spring I ordered the staff to move into our building which was not yet ready. I did that purposely:

settling down in the new building we would have to liquidate all the small defects as soon as possible. We began working in the laboratories before the parquet floors were laid.

In our laboratories we installed equipment we might need for serious scientific research not only today, but also tomorrow and the day after tomorrow.

We strove, as far as possible, to run ahead of life and be ready for any emergency. At the same time we tried to satisfy the needs of the day by quickly responding to them. The history of the birth of one of our first post-war models of welding tractor is typical in this connection.

Gas-holders were being installed along the Saratov-Moscow gas-main. Welding tractors of foreign manufacture ("Kjelberg" and "Linde") were used on the construction sites. The machines were too heavy and cumbersome and required special rail-tracks for their operation. Besides, they were no good for welding the inner and outer ring-seams of the gas-holders.

The gas-main builders needed a light and portable tractor capable of welding the circular seams inside the horizontal gas-holder. At the end of 1944, they asked us to design such a machine in the shortest possible time. This work was assigned to my son Vladimir. To achieve his aim he had to make several designs. The first model proved unsuccessful—the tractor was too complicated and unbalanced; it even turned over during welding.

On April 26, 1945, Vladimir started designing a new model. The representative of the gas-main came to see us every day and kept saying:

"I won't leave till I see the tractor ready."

Vladimir was anxious to design an apparatus, which would weld both the straight joint seams on the gas-holder and the circular seams inside. Together with two other comrades he had to do 20 sheets of the working design within a few days. They worked right through

the May holidays; on May 3, we examined and approved all the drawings. Those were the unforgettable days of the nation-wide triumph, when the entire country exulted and rejoiced at the end of the war and the victory over hated fascism.

During the meeting on Victory Day I asked Vladimir a single question:

"When will the complete design be ready?"

"On May 12," he answered.

It was the date we had fixed when starting work on the design.

Precisely at the appointed time—the middle of June—we were testing the first model of Tractor TC-6. It was small, light and stable, and accurately moved the electrode along the seam.

In less than a month the institute shipped the first consignment of these welding tractors to the construction sites of the Saratov-Moscow gas-main.

The gas-main builders were very happy about our present. Until then welding inside the gas-holder had been considered the most troublesome affair; the head had to be mounted on a long and inconvenient console and complicated fixtures had to be set up under field conditions. Now the small portable apparatus was taken through a hatch into the gas-holder, where it moved together with the enormous steel vessel and at the same rate, but only in the opposite direction. Actually the tractor stood in one place. This had always been considered impossible, and a certain respectable welding scientist made attempts to prove that this principle was impracticable even at the time our tractors were satisfactorily welding sections of gas-holders on the gas-main.

Months and years passed, and Tractor TC-6 acquired brethren: TC-11, TC-12, TC-13, etc. Each of these had its own merits, but it was only on the basis of all of them

that the universal Tractor TC-17 was born in time. This was an excellent and simple apparatus.

The history of the welding-tractor's birth to the order of the gas-main builders is only one of the many episodes, which show how our work in industry after the return to Kiev advanced our thinking and opened new opportunities for designers and technologists.

In the past we had repeatedly heard that the Institute of Electric Welding was an institute of the Academy of Sciences and yet was working on too narrow, too special a problem. We had always rejected this wrong reasoning. Now, that we had the war-time experience, and the institute specialized its themes even more, I believed we would always have to work mainly on automatizing and mechanizing the welding processes. This would be our pivotal problem. The work done in the Urals proved we were right.

We formulated our aim as follows: Concentrate, study and extend the possibilities of high-speed automatic flux-welding, and find ever new spheres and methods of applying it.

There were some people at the institute who did not agree with me and who thought that in the Urals we had been forced to circumscribe our investigations, but that now we had to extend them again. By this they usually implied the unnecessary and even harmful dissipation of our energies and themes. These people thought they were calling us ahead, but they were actually pulling us back and making us repeat certain pre-war mistakes.

We kept on our straight and narrow. Looking through our plans of that time today I am happy to note they all proved so vital as to determine the principal content of the institute's work for many years to come. To be sure, life corrected, altered and enriched these plans, but their main direction remained unchanged.

It would take too long to describe the way our extensive

programme, planned as early as 1944, was fulfilled. It would require dozens of pages. I shall cite but one example. During the 1944-1952 period the workers of the institute—Sevbo, Voloshkevich, V. Paton, Medovar, Lashkevich, B. Paton, Dudko, Rublevsky, Grebelnik, Podgayetsky and Leinachuk, along with the personnel of several plants, were awarded Government prizes. The high award marked six of our jobs: welding the armoured hulls of tanks, welding cisterns, new methods of factory and assembly welding of pipes, elaboration of a new method of semi-automatic "hose-welding," elaboration and production of new brands of welding-flux.

All this work had been done in accordance with the initial long-range thematic plan of the institute.

On May 9, the Day of Victory, we all looked back at the course we had travelled during the war and looked with joy at the path lying before us. Soviet tanks with welded seams were to be seen in the squares and streets of hundreds of cities in the countries liberated by the Red Army. These seams had stood the test with honour in numerous hard-fought battles. For us this was the highest reward for our work during the Great Patriotic War.

The grateful peoples of the East-European countries erected monuments to the army of liberation in their capitals and other cities. Red-starred tanks—veterans of victorious battles—crowned many of the pedestals. I saw pictures of these severe and majestic monuments and my heart beat faster, for those were our Urals tanks with seams welded by us, by our labour in the name of our Motherland.

Our soldiers will soon be back home, at their machines, tractors and combines, I thought. We, the welders, were called to peaceful work a year earlier. We have not wasted that time. We've made a good start; we've laid the basis, and the electric arc is already melting metal under flux in dozens of plants and on as many construction sites,

joining steel girders and pipes, parts of cisterns and carriages. Ahead of us there is an unprecedented scope of construction; the powers of the people have been released for peaceful constructive labour, for creative endeavour in all spheres of life. During the war I saw what our Soviet people were capable of, what immeasurable vitality they had. I never doubted they would prove themselves as strong when they exchange their tommy-guns and rifles of soldiers for the cutting tools of turners, the coal cutters of miners and the steering wheels of tractor drivers. We must show ourselves worthy of such people. There is only one way of doing it—work. A good deal of the work at the institute depends on me personally. I am 75 years old, but that does not mean anything. I am ready for more work and feel strong enough for it. I can still vie with my young co-workers. In creative problems age is not determined by the date indicated in the birth certificate, but by the ability and will to work, the ability to give all of oneself to the favourite work.

I thought thus in May, 1945; I continued to think and act thus in subsequent years...

I've brought my reminiscences up to 1945.

The eight years that have passed since Victory Day have been years of hard work for me and the workers of the institute I've headed. We've experimented a lot and have accomplished a good deal; to be sure, we've made mistakes and had mishaps, but we've tried to rectify our mistakes and have done the best we could.

It would require a book, perhaps no smaller than this one, to tell what we have done during the post-war years. I should very much like to write this book and tell my readers how we have learned to flux-weld automatically blast-furnaces, bridges, gas-mains, stators of turbo-generators, enormous reservoirs, ships, multi-storey build-

ings and agricultural machinery. I should like to tell my readers how surprisingly welding has extended its realm, how the science of welding developed and enriched itself, and how strong our friendship has become with hundreds of plants and construction sites.

Now, as I am writing these lines, I am 83 years old and no longer as strong as I was; I am seriously ill and can no longer work the way I used to or would like to. I find great satisfaction in that I have taught others to work, in that I have trained a generation of young scientists in the field of welding. These people are advancing our common work, and I am happy to see my sons among them.

I am setting great hopes on our talented youth. Most of our young workers have as yet relatively little scientific experience, but they have learned to work collectively and in harmony; they do not know any conceit, they appraise their successes critically and maintain close contact with life and production. This justifies my hopes that the Institute of Electric Welding, we created nearly 20 years ago, will continue to cope with its great tasks. . .[1]

Kiev, 1953

[1] In February, 1955, the E.O. Paton Institute of Electric Welding of the Ukrainian Academy of Sciences was awarded the Order of the Red Banner of Labour by Decree of the Presidium of the Supreme Soviet of the U.S.S.R. in connection with the 20th anniversary of its organization and its outstanding services to the development of electric welding.